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Integration of Blockchain-Based Smart Contracts for Sharia-Compliant Automation in Islamic Banking

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Abstract

The integration of blockchain-based smart contracts technology has emerged as an innovative solution in banking. The utilization of blockchain technology and smart contracts offers great potential in improving operational efficiency and compliance with Shariah principles in Islamic banking products. Overall, blockchain-based smart contracts have the potential to overhaul the traditional way of providing Islamic banking services, by providing more efficient, transparent, and inclusive solutions. This research emphasizes the need for technological readiness and supportive policies for the successful implementation of this technology in the Islamic banking sector. This article discusses the potential use of smart contracts in strengthening automation and sharia compliance in Islamic banking products, focusing on the role smart contracts can play in increasing Islamic financial inclusion and expanding access to Islamic banking services and how prepared Islamic financial institutions are to adopt blockchain technology and smart contracts. That way, the utilization of blockchain-based smart contracts integration can be seen as better to bring significant changes in the Islamic banking sector, both in terms of increasing efficiency and in strengthening sharia principles which are the main foundation of the Islamic financial system.

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KEYWORDS
Blockchain, smart contracts, Islamic banking, Shariah compliance

I. Introduction

In recent decades, the development of information technology and digitalization has brought significant changes in various industrial sectors, including the financial and banking sectors. One technological innovation that is increasingly attracting attention in the financial industry is blockchain and its application in the form of smart contracts. Blockchain, as the underlying technology of cryptocurrencies such as Bitcoin and Ethereum, has evolved into a solution that can improve transparency, efficiency, and security in financial transactions. Blockchain itself is defined as a technology that enables decentralized and secure data storage, allowing digital transactions or other data to be recorded in the form of interconnected and secure blocks. The term "blockchain" comes from two words: "block" and "chain".[1] Each block contains a certain amount of recorded information or data, and each block is connected or "chained" to the previous block through a cryptographic mechanism. This makes blockchain an innovative solution to issues related to data security, transparency, and system reliability.[2] Meanwhile, smart contracts are computer programs or codes that run on blockchain technology and are used to automate, verify, and enforce agreements or transactions that have been agreed between related parties. Smart contracts are created and executed based on predefined rules, without the need for intermediaries or third parties. These smart contracts ensure that a transaction or agreement will only be carried out if mutually agreed conditions are met. The concept of smart contracts was first introduced by cryptographer and computer scientist Nick Szabo in 1994.[3] Using blockchain as a platform, smart contracts offer a high level of security, transparency, and efficiency in managing transactions and agreements. Smart contracts allow interactions between two or more parties to be processed automatically, without the intervention of third parties such as banks, notaries, or lawyers.

In the context of Islamic banking, Islamic Banking has an important role in providing financial services that comply with Sharia principles, especially for people who avoid the conventional interest-based financial system. Sharia principles demand a

[1] Huayi Qi, Minghui Xu, Dongxiao Yu, Xiuzhen Cheng, "SoK : Privacy - Preserving Smart Contract", *High-Confidence Computing* 4 (2024) : 1-11, https://doi.org/10.1016/j.hcc.2023.100183
[2] Muhammad Izzul Syahmi Zulkepli, Mohammad Taqiuddin Mohamad, Saaidal Razalli Azzuhri, "Kontrak Pintar Berasaskan Blok Rantai Dari Perspektif Syariah", *Al-Basirah* 13, No. 2 (2023) : 01-12, https://doi.org/10.22452/basirah.vol13no2.1
[3] Azlin Alisa Ahmad, Mat Noor Mat Zain, Nur Diyana Amanina Zakaria, "The Position of Smart Contracts in the Light of Islamic Contract Theory", *Jurnal Hukum Keluarga dan Hukum Islam* 8, No. 1 (2024) : 144-171, https://doi.org/10.22373/sjhk.v8i1.16372

financial system that is free from riba (interest), gharar (excessive uncertainty), and maysir (speculation). However, while the Islamic finance industry continues to grow, there are still significant challenges in terms of financial inclusion and accessibility of Islamic banking services. Many individuals and small businesses in various countries, especially in developing regions, still face difficulties in accessing Islamic financial services due to limited infrastructure, complex bureaucracy, and high operational costs. Therefore, Islamic banking products must be designed to be Shariah-compliant and supervised by authorized authorities, such as the Sharia Supervisory Board. A key challenge in Islamic banking is to ensure that every financial transaction and product remains compliant with Sharia principles, without compromising on transaction efficiency and speed. In this regard, digital innovations such as blockchain-based smart contracts have the potential to be a solution to increase Islamic financial inclusion by providing services that are more efficient, secure, and accessible to more people.[4]

Smart contracts technology allows financial transactions and agreements to run automatically based on pre-programmed codes. By using smart contracts, Islamic banking products such as Murabahah financing (sale and purchase with an agreed profit margin), Mudarabah (investment partnership), and Ijarah can be carried out more transparently, quickly, and without complex intermediaries. smart contracts can be used to automate the recording of transactions, manage payments according to the agreement, and ensure that there is no element of usury or uncertainty in the contract. In addition, the implementation of blockchain in the Islamic banking system can improve efficiency in document management, and provide more transparent access for customers and regulators.[5] This can reduce transaction costs, speed up processing time, and reduce the risk of human error. Thus, the adoption of this technology can help Islamic banking reach more customers, including those living in remote areas or who previously did not have access to formal financial services.

However, while blockchain technology and smart contracts offer many benefits, the readiness of Islamic financial institutions to adopt them remains a big question mark. The application of these technologies in Islamic banking also faces several challenges, such as regulatory limitations, lack of understanding of the technology among stakeholders, as well as the need for integration with existing banking systems. As an institution that operates within a strict Shariah legal and regulatory framework, Islamic banking needs to ensure that any technological innovations adopted remain aligned with Shariah principles and can meet compliance standards set by regulatory authorities. In addition, it requires readiness in terms of technological infrastructure, human resources who understand both blockchain technology and Sharia banking principles, as well as

[4] Ahmad Fuadi Tanjung, Patma Wati, Nurlaila, "Penerapan Teknologi Blockchain Dalam Akuntansi Syariah", *Jurnal Masharif al-Syariah: Jurnal Ekonomi dan Perbankan Syariah* 8, No. 2 (2023) : 1218-1227, http://dx.doi.org/10.30651/jms.v8i2.19282

[5] Muhammad Akram Khan, "An Introduction To Islamic Economics", Saudi Arabian, *International of Islamic Thought And Institute Of Policy Studies* (1944).

support from regulators to create a conducive environment for the implementation of these innovations. Therefore, further studies are needed to explore how smart contracts can be optimally implemented in Islamic banking, without violating Shariah principles.

Based on this background, there are two main questions that are the focus of this research, namely **how can smart contracts increase Islamic financial inclusion and expand access to Islamic banking services?** Which discusses whether this technology can overcome accessibility constraints and infrastructure limitations that have hindered the growth of Islamic banking and how the implementation of smart contracts can make it easier for people to access Sharia financial services more transparently and efficiently. While the second discusses **how the readiness of Islamic financial institutions in adopting blockchain technology and smart contracts?** It discusses whether Islamic banking has sufficient infrastructure and resources to adopt these technologies, what are the regulatory and Shariah compliance challenges in implementing blockchain and smart contracts, and what steps need to be taken to accelerate the adoption of these technologies in the Islamic financial ecosystem. Through this discussion, it is hoped that the best solutions and strategies can be found to integrate blockchain technology and smart contracts in the Islamic banking system, so as to improve efficiency, transparency, and compliance with Shariah principles. In addition, this research will also provide insights into the readiness of the Islamic banking industry to face the era of digitalization and how this technology can be leveraged to drive the growth of the Islamic economy globally.

The discussion in this article also has objectives that are studied to describe the views of Islamic economics on the role of Blockchain-based smart contracts in banking, these objectives include analyzing how smart contracts can increase Islamic financial inclusion by expanding access to Islamic banking services, including mechanisms, benefits, and challenges in its implementation and evaluating the readiness of Islamic financial institutions in adopting blockchain technology and smart contracts, including aspects of regulation, infrastructure, human resources, and adaptation strategies to technological innovation.

II.Methods

This research uses a normative research method, which is an approach that focuses on the study of norms, principles, and regulations that apply in the context of Islamic banking and blockchain-based smart contracts technology. This method aims to analyze how the rules of Sharia law and principles can be linked to the development of digital technology in the Islamic finance industry. The normative research method in this study is carried out with a descriptive-analytical approach, which means that this research not only describes existing concepts and regulations, but also analyzes how smart contracts can be integrated in Islamic banking and assesses their suitability with Sharia principles.

This research uses secondary data obtained from various sources, including primary legal sources, namely regulations governing Islamic banking and financial technology, such as:

1. Fatwas of the National Sharia Council of the Indonesian Ulema Council (DSN-MUI) related to Sharia financial transactions.
2. Financial Services Authority (OJK) regulations on Islamic banking and financial technology (fintech).
3. Standards issued by international institutions such as Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI) and Islamic Financial Services Board (IFSB).

As well as obtaining data derived from secondary legal sources, namely literature and previous research that discusses blockchain, smart contracts, and their applications in the Islamic banking industry which include:

1. Academic journals and scientific articles that discuss blockchain technology and Islamic banking.
2. Books related to Islamic economics, Sharia financial regulations, and innovations in Sharia fintech.
3. Reports from research institutions and Islamic finance organizations on the development of digitalization in Islamic banking.

The analysis in this research is carried out using a qualitative method, in which data obtained from various sources of law and literature are analyzed systematically to answer the formulation of the problems that have been set. The analysis steps include, initially, concept identification and classification - Collecting and reviewing various basic concepts related to blockchain, smart contracts, and relevant Islamic banking regulations. Subsequently, interpretation of legal norms and Sharia principles - Analyzing how Sharia principles in Islamic finance can be integrated with smart contracts mechanisms in banking transactions. Next, evaluation of regulatory and industry readiness - Assess the extent to which existing regulations enable the implementation of blockchain technology in Islamic banking, as well as analyze the readiness of Islamic financial institutions to adopt this innovation. Finally, Synthesis and recommendations - Develop conclusions and recommendations related to the integration of smart contracts in Islamic banking based on the normative analysis that has been conducted.

By using this normative approach, the research is expected to provide an in-depth understanding of the legal aspects and Sharia compliance in the implementation of blockchain-based smart contracts, as well as offer solutions that can support the development of Islamic banking in the digital era.

III. Result and Discussion

Technology that becomes sophisticated makes one of the benchmarks for life to continue to develop and adjust to the convenience of everyone.[6] With the emergence of smart contracts in blockchain, it is easier for several sectors to handle things faster, including in the world of Islamic banking.[7] Based on the background that has been reviewed in this article, there is a formulation of problems such as how smart contracts can increase Islamic financial inclusion and expand access to Islamic banking services and how the readiness of Islamic financial institutions in adopting blockchain technology and smart contracts which will be reviewed in the discussion below.

1. The role of smart contracts in enhancing Islamic financial inclusion and expanding access to Islamic banking services

Islamic banking is growing rapidly along with the increasing demand for financial services that comply with sharia principles. One technological innovation that has the potential to strengthen this industry is blockchain-based smart contracts. Smart contracts are digital contracts that are executed automatically using programming code on top of blockchain technology. These contracts work based on predetermined rules and conditions, so they can run without the need for third-party intermediaries, such as notaries or legal institutions. In a nutshell, Smart contracts are digital contracts that are executed automatically based on pre-agreed programming code. These contracts run on blockchain technology, which ensures the validity and security of transactions without the need for third-party intermediaries. Blockchain is a distributed ledger that records transactions in a transparent and immutable manner. This technology guarantees data validity and reduces the risk of manipulation, making it suitable for the financial sector.[8] Smart contracts have key characteristics in various aspects, such as automation, where contracts are executed automatically according to pre-programmed conditions; security and transparency, where contract data stored on the blockchain is transparent and immutable; no intermediaries, which eliminates the need for third parties to verify and execute contracts; and efficiency and speed, where transactions can be processed faster than traditional contracts.[9]

Smart contracts have great potential in managing the risks of gharar (uncertainty), riba (interest), and maysir (speculation) in Islamic banking. Smart contracts have their

[6] Much Nurachmad, "Buku Pintar Memahami dan Membuat Surat Perjanjian", Jakarta, *Visimedia* (2010)
[7] Pascal Pichonnaz, "Principles on Blockchain Technology, Smart Contracts and Consumer Protection", Austria, *ELI : European Law Institute* (2022)
[8] Nuraini, "Analisis Perbandingan Efisiensi Pasar Keuangan Tradisional Dan Pasar Keuangan Berbasis Blockchain: Implikasi Untuk Transparansi Dan Keamanan Investasi", *Currency: Jurnal Ekonomi dan Perbankan Syariah* 2, No. 2 (2024) : 265-278, https://doi.org/10.32806/ccy.v2i2.242
[9] Don Tapscott, Alex Tapscott, "Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World",United Kingdom, *Penguin* (2016)

own advantages that can help Islamic banking in regulating Islamic finance, one of the advantages is transparency & clarity to reduce Gharar, smart contracts operate on top of the blockchain, so all contract rules and conditions are explicitly programmed and cannot be changed unilaterally. This reduces uncertainty (gharar) because all parties can verify the content and execution of the contract in real-time. Then another advantage is in automation and Sharia compliance so as to avoid Riba & Maysir, with the use of smart contracts allowing automation of transactions without the involvement of third parties, thus avoiding interest (usury) which often arises in conventional banking.[10] In addition, the execution of contracts based on agreed conditions reduces the element of speculation (maysir). Further advantages include efficient use and guaranteed security because by automating transactions, smart contracts eliminate the need for intermediaries such as banks or notaries, which can reduce operational costs and the risk of misuse. Data stored on the blockchain cannot be altered, thus increasing the trust and security of transactions. The application of smart contracts also adds auditability and regulatory compliance where the role of smart contracts records all transactions in a form that cannot be manipulated, thus facilitating supervision by Islamic financial authorities and ensuring compliance with sharia principles.[11] The benefits of implementing smart contracts that are useful in carrying out Islamic banking tasks such as, increasing Transparency, All transactions are recorded on the blockchain and cannot be manipulated; reducing Operational Costs, Eliminating the need for intermediaries and reducing administrative costs; increasing Efficiency, Transactions run automatically without delays or human intervention; increasing Sharia Compliance, Smart contracts can be programmed to avoid transactions that contain usury, gharar, or maysir; minimizing the Risk of Fraud, Data on the blockchain cannot be changed or deleted, thus reducing the risk of fraud.

Blockchain-based smart contracts offer a transparent, secure, and efficient solution, which can be applied in various sectors, including Islamic banking. However, Islamic banking also regulates the existence of Sharia principles in the use of Blockchain-based smart contracts, so for smart contracts to be used in Islamic banking, they must comply with the basic principles of Sharia. These principles include freedom from usury (interest) where transactions must not involve the payment or receipt of interest.[12] Then there is the freedom of transactions from Gharar (Uncertainty, so the contract must contain clarity in terms of specifications, duration, and expected results. Next, the

[10] Hatem A. El-Karanshawy, et. al, "Islamic Economics: Theory, Policy and Social Justice", Qatar, *Developing Inclusive and Sustainable Economic and Financial System* (2015)
[11] Chien-Hua Tsai, Dah-Kwei Liou, Hsiu-Li Lee, "Blockchain-supported online banking scheme", *Egyptian Informatics Journal* 27 (2024) : 1-16, https://doi.org/10.1016/j.eij.2024.100516
[12] Agus Setiawan, M. Sholeh Nurjaman, "Application Of Blockchain And Smart-Contract On Waqf Asset Management: Is It Necessary?", *Jurnal Keuangan dan Perbankan Syariah* 10, No. 2 (2022) : 85-101, https://doi.org/10.18860/ed.v10i2.15529

contract must be free from Maysir (Speculation), so the contract must not have an element of gambling or excessive speculation. And the contract must be based on Sharia Akad, so all transactions must use sharia contracts such as Murabahah (sale and purchase), Ijarah (rental), Musharakah (partnership), and Mudarabah (profit sharing). With the advantages and principles of blockchain-based smart contracts in Islamic banking, it is able to bind a standardized agreement which is then stored on a blockchain that has a network in Islamic banking directly. So that smart contracts have a significant role in the efficiency of Islamic banking. The application of smart contracts itself in Islamic banking can be applied in several agendas such as:

1. Smart Contracts for Murabahah Agreements (Sale and Purchase with Transparent Profits)
   In the Murabahah contract, Islamic banks purchase assets at the customer's request and resell them at an agreed profit.[13] Smart contracts can be used to record the agreed price, payment schedule, and sharia-compliant late fees. With blockchain, these transactions become more transparent and cannot be manipulated, minimizing disputes between banks and customers.
2. Smart Contracts for Mudarabah (Profit Sharing) Contracts
   In a Mudarabah contract, one party provides the capital (rabb al-mal) and the other party manages the business (mudharib). Smart contracts can ensure automatic profit sharing based on an agreed ratio without delay or fraud. All transactions and profit reports are recorded on the blockchain, increasing transparency and accountability.[14]
3. Smart Contracts for Musharakah (Partnership) Agreements
   In a Musharakah contract, two or more parties contribute to the capital of a venture and share the profits or losses based on the percentage of investment. Smart contracts can be used to record capital contributions, calculate profits based on financial statements, and distribute proceeds automatically. With blockchain, all transaction records cannot be altered or manipulated, increasing trust between business partners.
4. Smart Contracts for Ijarah (Leasing) Agreements
   In Ijarah contracts, assets are leased to customers with periodic payments. Smart contracts can automate lease payments and ensure that ownership of the asset remains with the bank until all payments are settled. In case of late payments, smart contracts can impose penalties that are channeled to social activities according to sharia principles.[15]

[13] Azharsyah Ibrahim, et. al., "Pengantar Ekonomi Islam", Jakarta, *Departemen Ekonomi dan Keuangan Syariah - Bank Indonesia* (2021)
[14] Monzer Kahf, "Lessons In Islamic Economics", Bangladesh, *Islamic Development Bank Islamic Research And Training Institute* (1991)
[15] Krisztián Bálint, "Blockchain and Smart Contract Creation for Efficient and Secure Data Storage of Consumer Habits and Logistics Data", Procedia Computer Science 253 (2025) 49–58, https://creativecommons.org/licenses/by-nc-nd/4.0

5. Smart Contracts for Zakat, Waqf, and Islamic Social Finance
   In Zakat, Smart contracts can automatically calculate and distribute zakat to the rightful recipients. Then in waqf, Blockchain can record waqf assets transparently and ensure that waqf funds are only used for permitted purposes. While in sadaqah and infaq, sadaqah and infaq transactions can be done through smart contracts to increase transparency and efficiency.

Blockchain-based smart contracts with their advantages can bring the benefits of time and energy efficiency from both parties, both from Islamic banking and the customers themselves. However, Smart contracts also have a limited scope in Islamic banking. **Initially,** the limitations of Smart Contracts in Handling Complex Uncertainty (Gharar in Fiqh Interpretation) in Islamic banking. Some aspects of Islamic banking transactions involve Islamic legal considerations that are subjective and require scholarly ijtihad. Code-based smart contracts cannot always handle this complexity, especially in cases where sharia interpretations may vary. **Subsequently,** Lack of Flexibility in Contract Modification. Smart contracts are immutable once implemented. If there is a change in sharia regulations or a change in business conditions, then a new contract must be drawn up, which can be inefficient.[16] **Next,** Dependence on Oracles & Validity of External Data. For certain transactions, smart contracts require external data (e.g. asset price in a murabaha contract). If the oracles (data sources) are not reliable, then there can be gharar in the contract. **Lastly,** Regulation & Acceptance of the Islamic Finance Industry. Although smart contracts are technologically promising, Islamic finance regulations in many countries have not explicitly accommodated their use. Cooperation between regulators, sharia scholars and technology developers is needed to ensure that the implementation of smart contracts is truly in accordance with Islamic principles.[17]

Smart contracts enable the automation of transactions without the involvement of a third party, thus avoiding interest (usury) that often arises in conventional banking. In addition, the execution of contracts based on agreed conditions reduces the element of speculation (maysir). The use of smart contracts in Islamic banking has a significant impact on transaction transparency and security.

1. Impact on Transparency
   Initially, the terms of the contract are written in code. Blockchain-based smart contracts allow all parties to see the rules and conditions of the transaction clearly before execution. This reduces gharar (uncertainty) as there is no ambiguity in the agreement. **subsequently,** they cannot be manipulated or changed unilaterally.

[16] Sebastián E. Peyrott, "An Introduction to Ethereum and Smart Contracts", Germany, *Autho* (2017)
[17] Vu Nguyen Huynh Anh, "An Organizational Modeling for Developing Smart Contracts on Blockchain-based Supply Chain Finance Systems", *Procedia Computer Science* 239 (2024) : 3-10, https://creativecommons.org/licenses/by-nc-nd/4.0

Once encoded and implemented on the blockchain, the contract cannot be changed without the consent of all parties. This increases trust between Islamic banks and customers. **Next,** Easier Auditability and Sharia Compliance. Every transaction is permanently and transparently recorded on the blockchain. Shariah regulators or auditors can easily trace transactions to ensure compliance with the principles of free riba, gharar, and maysir.

2. Impact on Security
   Initially, it reduces the risk of fraud and abuse. Since smart contracts are automatic and immutable, the risk of manipulation or fraud by either party is reduced. This is especially important in murabahah, ijarah, or musharakah contract-based transactions where clarity of agreement is needed. **Next,** Data Security & Privacy is Preserved. Blockchain uses high-level encryption technology to protect transaction data. Customer data can only be accessed by authorized parties, reducing the risk of information leakage.[18] **Lastly,** Automation Reduces Human Error. In the conventional banking system, manual input or processing errors can lead to disputes. With smart contracts, transactions will only occur if all pre-programmed conditions are met, reducing the possibility of human error.

Smart contracts can play an important role in increasing Islamic financial inclusion and expanding access to Islamic banking services in several key ways, such as reducing costs and increasing efficiency. There are two steps in this role: Process automation, where smart contracts eliminate the need for intermediaries such as banks or notaries in many transactions, meaning administrative and operational costs can be reduced. As well as the role of Affordable access because of the use of lower fees, Islamic financial services can be more easily accessed by low-income groups or micro-entrepreneurs who usually face cost constraints in the traditional banking system. The next role can be seen from the point of view of expanding reach to remote areas. Blockchain and smart contracts allow Islamic financial services to operate digitally, so that people in remote areas can access products such as microfinance, Islamic savings, and takaful insurance without having to come to the bank office.[19] Lau, the use of Blockchain-based Mobile Banking which allows for a wider reach in the use of smart phones, smart contracts can be used in blockchain-based mobile banking applications, providing access to Islamic financial services without geographical boundaries. Another important role of Blockchian-based smart contracts is to increase trust through transparency where smart contracts offer contracts that cannot be manipulated, so that all transactions and

[18] Denis Philippe, "Blockchain And Smart Contract: Lex Cryptographia ?", Luxembourg, *Philippe & Partners*, University of Paris Ouest (2022)
[19] Diva Khalishah Mutiara, Madian Muhammad Muchlis, "Dampak Teknologi Finansial Dalam Perbankan Syariah: Pendekatan Kualitatif Terhadap Perubahan Paradigma Dan Tantangan", *Journal Economic Excellence Ibnu Sina* 2, No.1 (2024) : 47-57, https://doi.org/10.59841/excellence.v2i1.911

agreements made with smart contracts are transparent and cannot be changed unilaterally, thus increasing public confidence in Islamic banking. Smart contracts in increasing public trust also provide auditability and sharia compliance, so that regulators and sharia scholars can easily audit smart contracts-based transactions to ensure compliance with sharia principles, which can increase the attractiveness of Islamic financial products. The next important role is the facilitation of more flexible Islamic Finance products. Smart contracts can automate financing schemes based on qard hasan (interest-free loans) or mudharabah (profit-sharing) contracts, making them more practical for small businesses. They can also be used in Islamic zakat, waqf, or peer-to-peer (P2P) lending platforms, allowing people to invest or donate more easily and safely. Finally, smart contracts can reduce risk and improve credit and fraud security. With transaction automation and permanent recording on the blockchain, smart contracts help reduce the risk of default and fraud that often occurs in conventional financial systems. Smart contracts can also eliminate Riba, Gharar, and Maysir automatically, Systems programmed according to Shariah principles can ensure that there is no element of usury (interest), gharar (excessive uncertainty), or maysir (speculation) in transactions.[20]

2. *Readiness of Islamic financial institutions to adopt blockchain technology and smart contracts*

Blockchain-based smart contracts bring significant developments to the scope of banking law, including Islamic banking law. The adoption of blockchain technology and smart contracts by Islamic financial institutions shows great potential in improving transparency, efficiency, and compliance with sharia principles. However, the readiness of these institutions to implement these technologies still faces various challenges Efficiency and Automation in Islamic Banking with Blockchain-based Smart Contracts provides significant considerations, such as the reduction of the involvement of intermediaries and operational costs in Islamic banking transactions, such as the involvement of third parties, such as fatwa institutions, notaries, or sharia lawyers. Here, Smart contracts eliminate the need for intermediaries by executing automated transactions based on pre-programmed sharia provisions. This reduces operational costs, saves time, and reduces the risk of human error.[21] As for the automation of Sharia

[20] Fabio Bassan, Maddalena Rabitti, "From smart legal contracts to contracts on blockchain: An empirical investigation", *Computer Law & Security Review: The International Journal of Technology Law and Practice* 55 (2024) : 1-25, https://doi.org/10.1016/j.clsr.2024.106035

[21] Norah M. Alshahrani, M.L.MatKiah,B.B.Zaidan, A. H. Alamoodi, Abdu Saif, "AReview of Smart Contract Blockchain Based on Multi-Criteria Analysis: Challenges and Motivations", *CMC : Computers, Materials, & Continua* 75, No. 2 (2023) : 2833-2858, https://doi.org/10.32604/cmc.2023.03613

Agreements, Smart contracts can be programmed to perform various contracts in Islamic banking, such as:

1. Murabahah (Sale and Purchase with a Known Profit)

   Smart contracts can ensure payments and delivery of assets are made as agreed. The profit and payment schedule are automatically recorded, reducing the risk of disputes.

2. Mudarabah (Profit Sharing between Capital Owner and Business Manager)

   Profits are automatically shared based on an agreed percentage, without the need for bank intervention. All transactions are transparently recorded on the blockchain.

3. Musharakah (Business Partnership with Shared Capital)

   Contracts can monitor each party's capital contribution and profit/loss sharing automatically. Avoid data manipulation by either party.

4. Ijarah (Leasing)

   Lease payments are made automatically on schedule. In case of late payment, smart contracts can apply penalties in accordance with sharia principles (for example, channeled to social activities).[22]

Smart contract itself has the efficiency of the problems in Waqf and Zakat that are regulated in banking law. If the distribution of zakat and waqf funds can be arranged automatically with smart contracts. Then all transactions are permanently recorded, increasing accountability and transparency. Smart contracts also increase security and transparency because Blockchain is immutable, so transaction data is more secure and cannot be manipulated. Sharia audits are easier to conduct because all transactions can be checked in real-time.[23] Reducing the risk of fraud because every party in the system can see accurate and transparent transaction records. With the many significant changes that occur in the process of implementing Islamic banking, it adds speed and efficiency to the current Transaction Processing such as Islamic banking transactions often require manual verification, which is time consuming and prone to errors. With smart contracts all stages can be accelerated because the transaction is executed automatically if the conditions have been met. For example, in the application of sharia-based home financing, the application, approval, and execution of the contract can be done in minutes, not days like traditional methods.

[22] Bin Hu, Zongyang Zhang, Jianwei Liu, Yizhong Liu, Jiayuan Yin, Rongxing Lu, Xiaodong Lin, "A comprehensive survey on smart contract construction and execution: paradigms, tools, and systems", *PATTERNS Review* 2 (2021) : 1-51, https://doi.org/10.1016/j.patter.2020.100179

[23] Winda Fitri, "Kajian Penerapan Smart Contract Syariah Dalam Blockchain: Peluang Dan Tantangan", *Jurnal JATISWARA* 38, No. 2 (2023) : 223-232, https://doi.org/10.29303/jtsw.v38i2.526

Blockchain-based smart contracts offer great opportunities for the effectiveness of problems in Islamic banking. For example, increased transparency and accountability: Blockchain technology enables transparent and immutable recording of transactions, thereby increasing trust and accountability in Islamic finance operations. Process Automation with Smart Contracts, use of smart contracts can execute financial agreements in accordance with Shariah principles automatically, reducing manual intervention and the potential for human error. And, Islamic Finance Product Innovation, adoption of this technology opens up opportunities to create new products and services that suit the needs of modern society, such as sharia crowdfunding and sharia-based peer-to-peer financing. Although with the many advantages in regulation related to the adoption of blockchain-based smart contracts, it provides convenience for banks to easily manage all problems that occur with customers and increase trust in banks that use the smart contract system, especially in Islamic banking itself. However, as good as the increasingly sophisticated technology is, in reality there are still difficulties with the use of smart contracts for its realization.[24] While smart contracts in Islamic banking offer many benefits, the implementation of smart contracts in Islamic banking faces several challenges such as, lack of clear regulations where regulations regarding blockchain and smart contracts in Islamic banking are still in the developmental stage. Integration with Islamic Financial Systems still need to adjust their systems to be compatible with blockchain technology. Fatwa and Legal Certainty There still needs to be a fatwa from Islamic authorities to ensure that smart contracts are fully compliant with sharia law. Security and reliability of the technology that although blockchain is known to be secure, there are still technical risks such as bugs in the code of smart contracts. And Low Level of Digital Literacy that many industry players and the public do not fully understand blockchain technology and smart contracts.

In addition to these general issues, the challenges that need to be faced in the use of smart contracts can be specifically categorized again in different problems, namely the existence of technical challenges and regulatory challenges. Technical challenges include the complexity of programming smart contracts. Smart contracts must fulfill sharia principles such as being free from usury, gharar (uncertainty), and maysir (speculation). Programming contracts based on sharia contracts (e.g. Murabahah, Mudarabah, and Ijarah) requires complex code to comply with Islamic regulations. If there is an error in the code, the contract may not be sharia-compliant, and it is difficult to fix because blockchain is immutable.[25] Another challenge is the Scalability and Efficiency of

[24] Shahbaz Siddiquia, Sufian Hameeda, Syed Attique Shahb, Abdul Kareem Khana, Adel Aneibab, "Smartcontract-based security architecture for collaborative services in municipal smartcities", *Journal of Systems Architecture* 135 (2023) : 1-17, https://doi.org/10.1016/j.sysarc.2022.102802

[25] Willion Lim, Steven Angkasa, Alexander Danelo Putra Wibowo, "Smart Contracts: Validitas Hukum dan Tantangan di Masa Depan Indonesia", *Jurnal Kewarganegaraan* 8, No. 1 (2024) : 829-838, https://doi.org/10.31316/jk.v8i1.6410

Blockchain Networks, where transaction speeds on public blockchains (such as Ethereum) are often slower than conventional banking systems due to consensus mechanisms that require validation by many parties. High gas fees (blockchain transaction fees) can be a barrier to the widespread use of smart contracts. There is a need for a more efficient and scalable blockchain to handle large transaction volumes in Islamic banking. As for the implementation challenges in the security and risk of Smart Contracts, blockchain-based Smart contract technology itself is vulnerable to hacking, bugs in the code, or security exploits. If there is a security gap in the smart contract code, Islamic banks can suffer huge losses without a clear recovery mechanism. Islamic banking needs to conduct periodic security audits of smart contracts to ensure there are no technical risks that can be abused. There are other challenges such as Integration with Existing Islamic Banking Infrastructure. Most Islamic banking systems still use traditional technology based on centralized databases, while blockchain is decentralized. Connecting smart contracts with legacy systems requires substantial investment, including infrastructure updates and human resource training. There is a need for interoperability standards so that smart contracts can integrate with core banking systems in Islamic banking.

With the development of technology adoption, the regulations also develop. However, in terms of implementation, there are still many challenges that need to be faced by regulations in Islamic Banking, such as the unclear regulations on Smart Contracts in Sharia Law, where there are no specific regulations governing smart contracts in Islamic finance. Authorities such as the National Sharia Council (DSN-MUI), AAOIFI (Accounting and Auditing Organization for Islamic Financial Institutions), and OJK need to issue guidelines regarding the use of blockchain technology in Islamic banking. Sharia fatwas and standards should be updated to cover blockchain-based transactions and smart contracts. There are challenges to compliance with Shariah Principles in contract automation. Shariah principles are flexible and often require human interpretation. Smart contracts work based on rigid codes without being able to take into account ethical values or flexible decisions that are usually taken by the Sharia Supervisory Board (DPS).[26] Challenges to Consumer Protection and Legal Security are also an issue with the procurement of blockchain-based smart contracts. In smart contracts-based transactions, legal liability becomes difficult due to the decentralized nature of blockchain. Such as Who is liable if something goes wrong in smart contracts? The developer? Or the Islamic Bank? Or the party who signed the contract? This question is a right that many laymen still question the effectiveness of this smart contrast. Thus, there is a need for regulations that establish clear legal responsibilities to protect customers from technological risks. With compliance to

[26] Cosimo Laneve, Claudio Sacerdoti Coen, "Analysis Of Smart Contracts Balances", *Blockchain: Research and Applications* 2 (2021) : 1-22, https://doi.org/10.1016/j.bcra.2021.100020

financial regulations, different countries have different regulations regarding blockchain and smart contracts. Countries like Malaysia and the United Arab Emirates have started to adopt blockchain regulations in Islamic finance, but many countries still do not have clear regulations. Islamic banks that want to use smart contracts must adjust to local regulations so as not to violate applicable laws.

Technically, the challenges that hinder the development of technology must have a solution that needs to be considered both technically in its application and in its regulation. The solutions that can be considered in solving the problems of implementing Blockchain-based smart contracts in their application are identified into two main solutions such as technical solutions[27] that prioritize the standardization of Sharia Akad in Smart Contracts. By developing smart contract templates that have been certified by the Sharia Supervisory Board. For example, by implementing a special Smart contract for Murabahah or Mudarabah that has been tested and is sharia compliant. Then there is the solution by using a more efficient blockchain. Choosing a blockchain with low transaction costs and high capacity, such as Hyperledger Fabric or Algorand, is more suitable for the Islamic financial system. Next, Periodic Security Audits. By auditing the smart contracts code by a third party to ensure there are no bugs or security holes. The solutions that need to be considered such as Interoperability with the Existing Islamic Banking System. Thus, developing APIs (Application Programming Interfaces) so that smart contracts can connect with existing core banking systems. As for the solution to the regulation of blockchain-based smart contract regulation, such as encouraging Regulation and Fatwa on Sharia Smart Contracts.[28] Sharia authorities such as DSN-MUI, AAOIFI, and financial regulators need to issue clear standards and fatwas regarding the use of smart contracts in Islamic banking. Then, Developing Hybrid Smart Contracts, smart contracts can be made with human intervention mechanisms under certain conditions to comply with flexible sharia principles. Meanwhile, Legal Protection for Customers. Where Islamic banking must work with regulators to establish a dispute resolution mechanism in smart contracts-based transactions. Finally, adopting Global Regulations that Support Sharia Blockchain, countries with strong Islamic finance industries, such as Malaysia, the United Arab Emirates, and Indonesia, need to form sharia blockchain regulations that can be adopted internationally. As for other solutions that can generally be considered in the Implementation of Smart Contracts in Islamic Banking to overcome these challenges, several steps can be taken such as collaboration between Sharia regulators and authorities such as the Central

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Bank, OJK, and Islamic institutions need to work together in developing clear regulations. Then, increasing technological literacy among Islamic scholars and financial practitioners so that they can understand and provide appropriate fatwas regarding the use of smart contracts. Next, the development of Islamic Blockchain Infrastructure by building a specialized blockchain network that complies with Islamic finance principles. Finally, Testing and Simulation, Islamic Banks can conduct small-scale trials of smart contracts before full implementation.[29] With regulatory support, technological innovation, and cooperation between Islamic financial institutions, smart contracts can be a key foundation for the future of digital Islamic banking, which is more efficient, transparent, and compliant with sharia principles.

IV. Conclusion

Blockchain-based smart contracts have great potential to improve efficiency, transparency, and sharia compliance in Islamic banking. With proper implementation and strong regulatory support, this technology can be an innovative solution for the Islamic finance industry. Smart contracts can accelerate Islamic financial inclusion by reducing costs, improving efficiency, expanding digital access, and building trust through transparency and security. With wider adoption, this technology can help more people gain access to Islamic financial services, including those previously unreached by the traditional banking system. By reducing the involvement of intermediaries, automating sharia contracts, and increasing transparency, these technologies can help Islamic banks provide faster, safer, and sharia-compliant services. However, the successful implementation of smart contracts depends on regulatory support, industry readiness, and clarity of sharia fatwa. If these challenges can be overcome, smart contracts could become a key foundation for the future of digital Islamic banking. While blockchain technology and smart contracts offer various advantages to Islamic financial institutions, their adoption is still in its early stages and faces a number of significant challenges. Collaboration between regulators, industry practitioners, and academics is needed to develop a framework that supports the effective implementation of these technologies in accordance with Shariah principles.

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