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Smart Contract Technology Potential in Mitigating Defects of Islamic Banks' Tawarruq Operations

Potensi Teknologi Kontrak Pintar dalam Mengatasi Kekurangan Operasi *Tawarruq* di Perbankan Islam

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ABSTRACT

Smart contracts are computer codes that represent contract terms and are designed to run on a blockchain platform, automatically enforced upon receiving predetermined inputs. This technological innovation, a key component of the Fourth Industrial Revolution, provides an advanced and innovative approach to executing contract terms. Incorporating this technology into Shariah-compliant contracts within Islamic Banks (IBs) holds the potential to reduce Shariah non-compliance risk (SNC) and enhance operational transparency, ensuring compatibility with contemporary technological applications. In particular, blockchain-based smart contracts have the potential to be integrated into the operations of IBs' products that are based on tawarruq contracts. This study aims to investigate the potential application of blockchain-based smart contract technology in tawarruq contract operations within IBs and to suggest directions for future research. This study adopted a qualitative approach, drawing on relevant literature. The findings indicated that blockchain-based smart contracts can address Shariah Non-Compliance (SNC) issues in IB's tawarruq operations while enhancing transaction transparency. This paper discussed the Shariah and operational challenges associated with blockchain technology and posits that blockchain-based smart contracts can improve the practices of tawarruq contracts within Islamic Banks. This paper offers insights for IB entities and regulatory authorities to evaluate the potential and impact of blockchain-based smart contracts within their operations and the broader financial system.

Keywords: Blockchain; Industrial Revolution 4.0; Islamic financial institutions; smart contract; tawarruq

ABSTRAK

Kontrak pintar ialah kod komputer yang mewakili terma kontrak, direka untuk dilaksanakan melalui platform blok rantai dan dikuatkuasakan secara automatik apabila menerima input yang telah ditetapkan. Inovasi teknologi ini, sebagai salah satu komponen utama Revolusi Perindustrian Keempat, menawarkan pendekatan yang maju dan inovatif dalam pelaksanaan terma kontrak. Penggabungan teknologi ini ke dalam operasi kontrak Syariah Bank Islam (BI) berpotensi mengurangkan isu ketidakpatuhan Syariah (SNC) dan meningkatkan ketelusan operasi dan memastikan keserasian institusi tersebut dengan aplikasi teknologi kontemporari. Khususnya, kontrak pintar berasaskan rantaian blok mempunyai potensi untuk diintegrasikan ke dalam operasi produk BI yang berasaskan kontrak tawarruq. Kajian ini mempunyai dua tujuan. Pertama, meneroka potensi teknologi kontrak pintar berasaskan blok rantai dalam operasi kontrak tawarruq di BI. Kedua, mencadangkan hala tuju bagi penyelidikan masa hadapan. Kajian ini menggunakan pendekatan kualitatif dengan merujuk kepada literatur yang berkaitan. Dapatan kajian menunjukkan bahawa kontrak pintar berasaskan blok rantai boleh menangani isu Ketidakpatuhan Syariah (SNC) dalam operasi tawarruq BI serta

meningkatkan ketelusan transaksi. Dengan menangani cabaran Syariah dan operasi yang dikaitkan dengan teknologi ini, kajian ini menyatakan bahawa kontrak pintar berasaskan blok rantai dapat menambah baik amalan kontrak tawarruq di BI. Kajian ini menyumbang pandangan bernilai kepada entiti BI dan pihak pengawalselia dalam menilai potensi serta kesan kontrak pintar berasaskan blok rantai dalam operasi institusi mereka dan sistem kewangan yang lebih luas.

Kata kunci: Blockchain; institusi kewangan Islam; kontrak pintar; Revolusi Perindustrian 4.0; tawarruq

INTRODUCTION

The concept of smart contract, which is blockchain-based, refers to a computerized transaction protocol that satisfies contractual conditions and operates on a blockchain platform or a similar distributed infrastructure. Once predefined actions are triggered, the transaction undergoes validation and decentralization throughout the blockchain network. The resulting record is then transparently distributed among the network nodes.

The digital transformation of the financial sector and the rise of fintech are reshaping the operational landscape and model of Islamic financial institutions. Smart contracts and blockchain technology enable the prudent execution of contracts without the need for intervention by authorities (Peters and Panayi 2016; Eze and Okpara 2017). Ongoing industry research and efforts to integrate financial technology, including smart contracts and blockchain technology, into the provision of financial services are on the rise (Todorof 2018; Yuneline 2022).

In Malaysia, the Central Bank issued the Financial Technology Regulatory Sandbox Framework on October 18, 2016 (BNM 2016), and subsequently, on December 31, 2020, issued the Policy Document on Licensing Framework for Digital Banks (BNM 2020). This initiative aims to assess the risks associated with financial technology, ensuring a secure and conducive financial technology environment in Malaysia, while also supporting the rapid advancement of financial technology worldwide.

In the financial industry, there is a notable emergence of initiatives integrating blockchain-based smart contracts into various products and services. Notably, a successful application has been realized in the realm of trade finance, as documented by Hilal and Jamaluddin (2019). HSBC, in 2019, conducted a successful pilot of Malaysia's initial blockchain-based Letter of Credit transaction through the utilization of Contour, a blockchain-based platform, as reported by Anwar (2021). The incorporation of blockchain technology has effectively facilitated accelerated cross-border trade operations, significantly enhancing working capital efficiency.

The proliferation of fintech start-up enterprises has implications for the sustainability of Islamic financial institutions. These start-ups have ventured into providing financial services such as deposit-taking and financing through advanced technology, including smart contracts and blockchain (Milian 2019). Their ability to facilitate the execution of contracts between unfamiliar parties efficiently, in terms of processes and costs, is noteworthy.

The global technological advancements have prompted a shift in people's preferences toward technology adoption in their daily routines, including financial activities. According to Statista, the usage of internet and mobile banking is expected to witness a substantial increase in the far east and China, projecting one billion online banking customers by 2024, up from 800 million in 2020 (Statista 2022). These findings indicate a growing technological literacy in society. The public is anticipated to favor quicker and more efficient digital financial services channels, eliminating the need for physical procedures in the future, over traditional banking channels, owing to extensive and rapid technological exposure (Eduardo et al. 2019). Moreover, this underscores the importance of integrating current Industry Revolution 4.0 (IR 4.0) technologies into the financial ecosystem, potentially replacing traditional technologies to ensure preparedness for the challenges of the twenty-first century.

Smart contracts may encompass any contractual term, including Shariah contracts within Islamic financial institutions. Muneeza and Mustapha (2019), Habib (2019), Elasrag (2019), and Rahim et al. (2018) have advocated for the implementation of smart contracts in Islamic banking (IB) products offering operations via Shariah contract-based products. Several studies also explore the potential integration of blockchain-based smart contracts in *tawarruq* or commodity *murabaḥah* operations within Islamic financial institutions. This integration has the potential to enhance operational transparency, reduce operational expenses, and minimize human errors.

In response to the BNM circular on *bay' al-'inah* (sale and buy-back), leading to a significant tightening of the Shariah requirements of *bay' al-'inah* products, *tawarruq*-based products have experienced rapid growth, becoming one of the most widely used concepts in the Malaysian IBs system in recent years (Hasmad & Alosman 2022). As reported by BNM (2022), *tawarruq* contracts have contributed significantly to the annual rise in revenue for IBs products between 2019 and 2022, with increases of 11% for financing, 22% for deposits, and 7% for interbank money market instruments.

The prominence of *tawarruq* contracts in the product operations of Malaysian IBs highlights their ability to meet the operational nature and customer needs of IBs. However, *tawarruq* has been identified as the highest Shariah non-compliant (SNC) incident, according to Mohamad (2014) and a survey by Ali and Hassan (2020) that produced consistent findings. With the emergence of blockchain-based smart contract technology, it has the potential to serve as a viable operational approach to mitigate SNC risk in IBs' *tawarruq* operations.

The primary aim of this paper is to conduct a comprehensive review of the existing literature concerning the potential application of blockchain-based smart contract technology in the operational processes of Islamic Banks (IBs) with regard to *tawarruq* contracts. Furthermore, the paper will propose potential avenues for future research on this topic. The research is guided by the following questions:

R1. How can blockchain-based smart contracts be integrated into the *tawarruq* contract operations of IBs?

R2. What further research areas can be explored to facilitate the implementation of blockchain-based smart contracts in *tawarruq* operations within IBs?

LITERATURE REVIEW

UNDERSTANDING BLOCKCHAIN-BASED SMART CONTRACTS

In 1996, Nick Szabo (1997) initially defined a smart contract as a "a set of promises specified in digital form, including protocols within which the parties perform on these promises." The term "smart" denotes a more functional nature compared to traditional paper-based contracts.

Recent research suggests that the definition of smart contracts has evolved to refer to a set of protocols arranged in an "if-then" format that operates on a blockchain network (Ante 2021). The terms "smart contract" and "blockchain" are often used interchangeably due to the integration of smart contracts into blockchain technology, notably by leading providers such as Ethereum and Hyperledger.

The advancement of blockchain technology to blockchain 2.0 not only facilitates cryptocurrency transactions but also enables the execution of smart contract protocols (Giancaspro 2017). This transformative technology provides a secure peer-to-peer framework for value transfers and embraces the distributed infrastructure necessary for smart contract execution (Ante 2021).

Smart contracts are capable of autonomously executing transactions through automated enforcement, community-driven decentralized verification on the blockchain, and distributed transaction records (Kasmon et al. 2023).

The lifecycle of smart contracts comprises four sequential phases, as follows:

1. Contract agreement: All involved parties should negotiate and discuss to reach an agreement that specifies contract obligations, rights, and limitations. This can be facilitated with the help of lawyers or consultants. The agreement may be reached using a smart contract platform, a digital platform linked to a smart contract platform, or through physical documents.
2. Creation of smart contract: Once an agreement is reached, software experts will transform the agreement into a smart contract written in computer languages. This process follows the same steps as software development: design, implementation, and validation through testing. Smart contract development involves collaboration with stakeholders, lawyers, and software engineers in an iterative process.
3. Deployment of smart contracts: After validation, the smart contract is deployed on the blockchain network. Since the blockchain is immutable, smart contract codes stored on it cannot be altered. Once deployed, all parties can access the contract and the digital assets of both parties are locked by freezing the corresponding digital wallets.
4. Execution of smart contracts: The contractual procedures or functions are automatically executed after the smart contract is deployed

on the blockchain. The smart contract codes are made up of logical declarative statements, and when conditions are met, the related statements are automatically processed, resulting in transaction execution. These transactions are validated by the communities in the blockchain network through the blockchain consensus protocol and the committed transactions and modified states are stored on the blockchain.

5. Completion of smart contracts: After the execution of a smart contract, all involved parties are updated with new states. At this point, the digital assets of the parties involved will be unlocked and transferred as per the terms of the contract. It's important to note that all the details of a smart contract's deployment, execution, and completion are recorded in the blockchain, ensuring transparency and security.

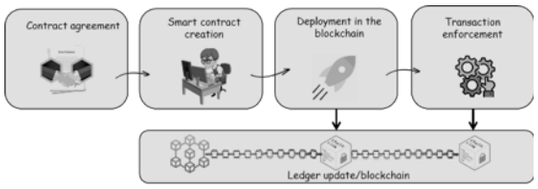

FIGURE 1. A Lifecycle of a Blockchain-Based Smart Contract
Sources: Adapted from Zheng et al. (2019), Feng et al. (2019), Hilal and Jamaludin (2019).

The implementation of a blockchain-based smart contract hinges on the enforcement of pre-coded terms. This emerging technology offers the potential for contracts to be executed without human intervention. Smart contract coding possesses distinct characteristics that ensure the proper execution of all transactions.

Decentralization stands as a key value of this technology, with transaction validation occurring through nodes within the blockchain network. Smart contract mechanisms and blockchain operations play complementary roles in guaranteeing the integrity of the transaction process, circumventing the need for centralized authority. Nodes, responsible for validating blockchain transactions through specific consensus protocols, receive rewards as a result. The consensus protocols and reward mechanisms may vary in public and private blockchains.

Upon successful validation, the recorded data is distributed across the blockchain, granting all connected nodes real-time access. Notably, this technology does not rely on a single central server.

Beyond automating transaction enforcement through smart contracts, blockchain mechanisms facilitate the effective realization of non-human-intervention and transparent transaction operations. The advent of blockchain-based smart contracts signals a new era in contract execution, promising increased efficiency and reduced operating costs.

UNDERSTANDING *TAWARRUQ'S* OPERATION IN IBs

The conventional *tawarruq* arrangement involves two separate contracts. An individual seeking liquidity acquires a commodity on credit and then seeks a third party to purchase it from them at a spot price. This results in the individual obtaining cash and incurring a larger debt than the cash amount (Shafie et al. 2020). Islamic banks (IBs) have adapted and modified this contract, known as *tawarruq munazzam* (organized *tawarruq*), wherein the IBs act as the agent of the original buyer in finding a buyer for the subsequent sale and incorporate pre-arranged elements (Hasan, 2011).

Tawarruq contracts are extensively utilized in IBs' products, inclusive of deposit-taking and financing products. Typically, there are four parties involved in IBs' *tawarruq* contracts. In financing products, banks are required to first purchase the commodity before engaging in a *tawarruq* transaction with the customer, as IBs do not possess commodities to vend to their customers. The same applies to deposit products, wherein customers purchase the commodity before entering into a transaction with the bank.

Figure 2 illustrates the *tawarruq* transaction in IBs.

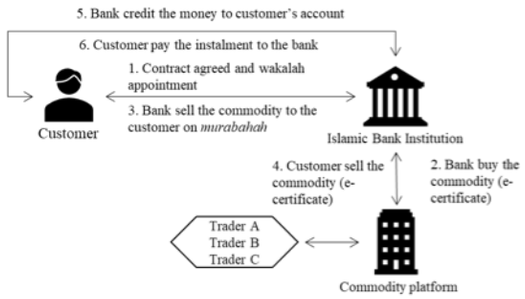

FIGURE 2. *Tawarruq* Operation in IBs' (Financing)
Source: Adapted from Ahmad et al. (2017), Mahyudin and Che Seman (2019).

The common commodity used in Malaysia is Crude Palm Oil (CPO) made available by Bursa Suq al-Sila' (BSAS). Other platforms used by IBs for *tawarruq* transactions are LME, Sedania, Able Ace which all of them has their own operation

systems. The commodity platform systems will link commodity suppliers and buyers, maintaining the Shariah-complaint transactions, as well as provide e-certificates to the participants as evidence of transactions occurred.

BSAS's most recent system is called the 'straight through process' (STP). The technology enables IBs to automate commodity *murabaḥah* transactions in the system via step-by-step instruction in sequence and in multiple submissions into the BSAS system or blanket instruction to proceed with the leg 1,2, and 3 commodity transactions in a single submission of transaction data into the BSAS system (Ahmad et al. 2020; Hiroshi 2021).

SHARIAH ISSUES RELATED TO IBs' *TAWARRUQ* OPERATIONS

The contemporary operational practices of *tawarruq* contracts in Islamic banks and the Shariah-related challenges that they encounter have been extensively researched. Mohamad (2014) has pointed out that due to the complex nature of *tawarruq* financing, it is more susceptible to Shariah non-compliance (SNC) events compared to other types of Shariah contracts. Zaharudin and Abdullah (2022) have also highlighted the frequent occurrence of issues related to improper transaction sequences in *tawarruq* operations within Islamic banks (IBs).

A study conducted by Ali and Hassan (2020) revealed that the most prevalent SNC event in *tawarruq* financing is the improper sequence of the sale contract. This includes the sale of the asset to the customer before the bank purchases it from the broker, advance disbursement of the facility prior to the complete execution of the *tawarruq* transaction, improper price disclosure, absence of a *wakalah* agreement, imposition of a higher *ta'wid* (compensation) than the actual cost, delivery restrictions, and absence of a new contract in the renewal of the *tawarruq* facility.

Moreover, Mohd Nor et al. (2020) and Nor et al. (2020) have documented numerous instances of SNC in *tawarruq* operations in Islamic banks, such as scenarios involving no actual buying or selling of commodities, lack of clear agreement between contract participants before the *tawarruq* transaction, and insufficient commodities being traded in the *tawarruq* transaction between the contract participants.

In a study focused on Maybank Islamic Berhad, Mohamad and Ab Rahman (2014) discovered that SNC events in *tawarruq* financing can occur at various stages and processes, including credit application, documentation, client engagement, withdrawal, credit monitoring, and credit recovery (rescheduling and restructuring). Notably, Mohamad (2014) emphasized the execution of the *tawarruq* contract before the bank actually owns the commodity as one of the issues linked to the improper sequence of *tawarruq* financing in Islamic banks.

The issue of conflict of interest related to dual-agency practices in *tawarruq* operations in Islamic banking is reported to be non-existent, based on a survey conducted by Zulkepli and Mohamad (2020). However, it is essential to exercise caution and attention to ensure that each transaction process adheres to *tawarruq* operation requirements, specifically in terms of the correct sequence of transactions (Shaharuddin et al. 2020; Ismail et al. 2016).

Zulkepli, Mohamad, and Hussin (2023) have highlighted the issue of *bay' wa salaf* (combination of a sale and a loan) and the potential of providing profits to customers without *tawarruq* transactions, particularly in the context of deposit products. They attributed these issues to the negligence of Islamic banking staff and system faults that led to improper execution of *tawarruq* transactions, thereby inviting criticism of Islamic banks' operations.

The SNC incident in *tawarruq* operations in Islamic banks occurred due to commodities not being the primary focus of the *tawarruq* contract participants. This involved a series of sales and purchases contracts that needed to be conducted in a well-ordered manner and in compliance with Shariah rules (Syahmi et al. 2022; Mohamad and Ab. Rahman 2014; Billah 2015). Meanwhile, challenges related to Shariah non-compliance in *tawarruq* operations in Islamic banks often stem from staff misconduct, physical procedures, and unsustainable systems (Ali and Hassan, 2020). As a result, it is imperative to implement enhanced control of Islamic banks' *tawarruq* operations, including the establishment of a robust system to address emerging Shariah issues (Hasmad and Alosman 2022; Zaharudin and Abdullah 2022; Mahyudin and Seman 2018).

METHODS

The study's methodology is rooted in a qualitative research technique that allows for thorough examination of various subjects and a comprehensive interpretation of the subject matter (Aspers and Corte, 2019).

Merriam and Grenier (2019) propose one method for qualitative research which involves gathering data through library research. This approach entails collecting data from diverse sources, including technical books on smart contract technology, journals, conference papers and proceedings, reports, and relevant websites. Given the accessibility of the research subject, the researchers conducted an extensive analysis of the collected data.

This study utilizes both the explanatory research methodology and inductive reasoning to analyze data. Inductive reasoning, as suggested by Lodico et al. (2010), entails constructing an abstraction or describing a phenomenon based on observations, thereby adopting a 'bottom-up' approach to achieve comprehension. The research focuses on previous scholars' ideas about smart contract technology and its potential application in tawarruq operations. The explanatory research approach, according to Cooper and Schindler (2001), is particularly advantageous for this study as it provides a thorough understanding of the subject matter. This approach enables the researchers to elucidate scholars' viewpoints on smart contracts and their concerns regarding tawarruq operations utilizing smart contract technology. Moreover, it allows the researchers to delve into a previously under-researched area, offering new insights and findings on Shariah aspects.

RESULT AND DISCUSSION

TAWARRUQ CONTRACT OPERATION IDEAS THROUGH BLOCKCHAIN-BASED SMART CONTRACT TECHNOLOGY

The emergence of blockchain-based smart contract platforms has significantly influenced the financial services industry, particularly in facilitating lending and borrowing activities through decentralized applications (dapps) in today's data-centric environment. Notably, within the scope of Islamic finance, the utilization of blockchain-based smart contracts presents an opportunity to facilitate Shariah contract transactions. Various studies, such as those conducted by Laldin and Furqani (2019), Muneeza and Mustapha (2019), Roslan et al. (2020), and Habib (2019), have suggested the potential of smart contracts in initiating transactions within Islamic financial institutions.

Upon reaching mutual agreement, the contractual processes must be translated into code and deployed on the blockchain network. Subsequently, when predefined conditions, such as investment maturity dates, are met in accordance with the contract terms, the transaction is automatically executed, validated by the network community, and the relevant records are stored and distributed across the network. Notably, the application of *tawarruq* through blockchain-based smart contracts is an innovative concept, involving the enforcement and governance of *tawarruq* requirements via smart contract code and verification through a consensus protocol to form a chain in a blockchain transaction record.

Furthermore, smart contracts can also be employed to implement *tawarruq* contracts. Figure 3 demonstrates the operation of *tawarruq* using a smart contract. The concept of executing *tawarruq* operations via smart contract is supported by prior research and the current operations of blockchain and smart contract providers in various products and services.

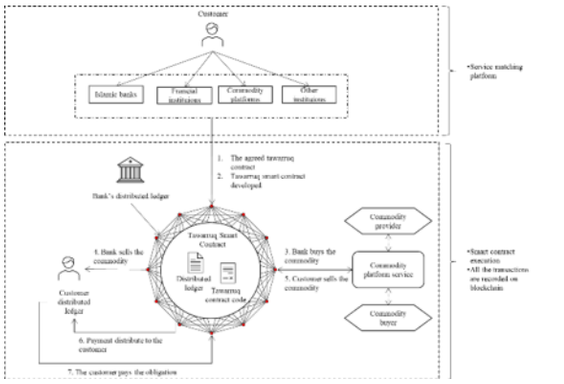

FIGURE 3. Idea of *Tawarruq* Operation on Blockchain-Based Smart Contract
Sources: Adapted from Roslan et al. (2020), Muneeza and Mustapha (2019)

In Figure 3, the current methods for finalizing the client product application, risk assessment, product offering, and contract agreement can be employed. However, within the realm of digital banking operations, a range of financial technology mechanisms, such as e-KYC, big data, artificial intelligence, and self-recognition, can be assimilated to streamline processes (Roslan et al. 2020). Fortunately, modern technology can simplify the entire process of reaching an agreement among the customer, and any other involved parties.

Upon reaching the agreement, the contract terms, including the involved parties, the process, and any additional conditions, must be documented in the form of a smart contract (referred to in this

research as a "*tawarruq* smart contract") and the code deployed on the blockchain. The *tawarruq* smart contract will oversee the subsequent processes upon receiving a specific input conforming to the smart contract's terms (e.g., commodity purchase from the supplier) and will be supervised by the decentralized blockchain system without human intervention post-deployment of the code. Upon completion of the *tawarruq* transaction, customers will receive the cash payment through pre-established channels. Subsequently, the installment payment to the finance provider will be executed according to the agreement, and the payment will be made in a pre-arranged manner using the smart contract.

BENEFIT OF USING BLOCKCHAIN-BASED SMART CONTRACT TECHNOLOGY ON IBs' *TAWARRUQ* OPERATIONS

The *tawarruq* contract participants' primary objective is not commodities, and the transaction involves multiple transactions, necessitating a robust system and operational mechanisms to reduce SNC events (Hasmad and Alosman 2022; Zaharudin and Abdullah 2022; Mahyudin and Seman 2018). Introducing blockchain-based smart contract technology can potentially address these challenges by providing an alternative that ensures compliance with Shariah contract requirements. Leveraging blockchain-based smart contracts may mitigate the probability of operational errors and improper sequences in *tawarruq* transactions, such as the premature selling of commodities to clients before the bank possesses them and disbursing funds before the completion of the *tawarruq* transaction (Ali and Hassan 2020; Izhar 2010; Ali and Hassan 2020). Unlike human-executed transactions prone to errors, smart contracts operate exclusively based on incorruptible computer code, thereby eliminating the potential for human errors. The smart contract ecosystem can effectively manage transaction failures and deviations from preset sequences (Hewa et al. 2021; Roslan et al. 2020). Figure 4 illustrates the process through which a smart contract executes a transaction:

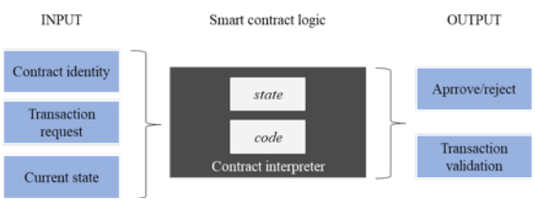

FIGURE 4. Smart Contract Ecosystem
Source: Adapted from Nguyen et al. (2020).

In the context of smart contracts, as illustrated in Figure 4, inputs, contract interpreters, and outputs are integral components. According to Nguyen et al. (2020), when an input is received by the contract interpreter, it promptly verifies its authenticity. Should the submitted input contravene the encoded provisions of the smart contract, the transaction order is rejected. Conversely, compliance of the input with the programmed codes results in the generation of the transaction output. This structured framework and transaction platform is particularly conducive for *tawarruq* contracts, which entail multiple sequential sale and purchase transactions to circumvent Shariah non-compliant occurrences (Roslan et al. 2020).

The blockchain ecosystem plays a pivotal role in upholding transaction legitimacy. The blockchain community, in accordance with the established consensus protocol, meticulously validates various facets of the transaction, encompassing the contractual logic and transaction assets (Feng et al. 2019). The operational aspects of *tawarruq* transactions, involving the exchange of commodities, stand to benefit significantly from the blockchain environment.

Blockchain-based smart contract technology also affords the advantage of enhancing transaction transparency (Hartel and Van 2019), a facet that has not been fully realized heretofore (Schar 2021). The decentralized validation of every transaction by the blockchain community substantially augments transaction transparency. The community ensures that all transactions are meticulously documented in the blockchain (Mann et al. 2018; Hartel and Van 2019).

Furthermore, blockchain technology furnishes real-time data pertaining to *tawarruq* transactions to all nodes in the blockchain network (Habib 2019). Once all transactions are executed and validated by the blockchain community, the records are systematically inscribed across the distributed blockchain network (El Amri et al. 2021). As a result, all network nodes have access to real-time data. Each blockchain platform features its own blockchain explorer, allowing users to access real-time data and transaction history. For instance, Etherscan (Etherscan n.d) serves as a blockchain explorer for the Ethereum platform.

The implementation of blockchain technology has the potential to enhance *tawarruq* operations in Islamic banks (IBs). By storing transaction details in the form of electronic certificates or paperwork on

IBs' servers, customers can access this information upon request (Mahyudin and Seman, 2018). While traditional record-keeping practices by banks do not raise Shariah-related concerns, the transparency offered by the blockchain ecosystem is likely to positively influence customer perceptions of IBs' operations.

Utilizing *tawarruq* on a blockchain-based smart contract ensures adherence to Shariah principles. Having elucidated the functioning of *tawarruq* on a blockchain-based smart contract, the paper will now shift its focus toward providing recommendations and suggesting future research directions.

RECOMMENDATIONS AND FUTURE RESEARCH DIRECTION

In accordance with the previously provided overview, it is feasible to execute *tawarruq* contracts through blockchain-based smart contract technology, subject to the capability of this technology to address Shariah-related concerns. However, given its distinct operational environment compared to Islamic banking operations, several challenges need to be explored before its application. This section advises an examination of Shariah and operational issues.

A critical challenge to be addressed is the organization and presentation of the offer and acceptance of *tawarruq* contract participants within smart contract code (Zain et al. 2019; Habib 2019). Shariah scholars must thoroughly address the absence of contracting parties, contract sessions, and the validity of general consent for automated transactions without considering sub-transactions within the context of self-executing smart contracts. Furthermore, the accurate translation of legal terminology into software logic needs attention (Mohamed and Ali 2021; Ante 2021), along with concerns about the presence of *gharar* and additional restrictions (Habib 2019).

Another issue arises from off-chain asset transactions using blockchain-based smart contracts. While such technology is effective for on-chain operations, it cannot regulate off-chain transactions (Safina and Oseni 2019; Nguyen et al. 2020). Aligning off-chain and on-chain operations presents challenges, as misalignment may lead to Shariah prohibitions, potentially invalidating the transaction. To facilitate transactions involving off-chain assets, such as *tawarruq* contracts, parties must incorporate a crypto anchor or operational mechanism to enable smart contracts to recognize off-chain asset transactions (Amanie 2019).

Research in this area has proposed the use of digital tokens to back up off-chain assets (Roslan et al. 2020; Marchesi et al. 2020; Batoletti and Pompianu 2017; Eza et al. 2017). An important aspect is the simultaneous identification of tangible assets backed by digital tokens. In the context of Islamic banks' *tawarruq* operations, the e-certificate representing the physical asset transaction can serve as one of the crypto anchors. To facilitate this, it is recommended to convert the e-certificate data using a specific approach, such as hashing, as suggested by Rahardja et al. (2021), to enable the smart contract and blockchain to access it. Further research into the feasibility of this approach is necessary.

Smart contracts' immutability presents challenges, particularly in the inclusion of rescheduling, restructuring, and termination clauses in Islamic banking products, specifically *tawarruq* contracts (Muneem et al. 2020; Anam et al. 2022). The immutability and irreversibility of blockchain technology make it difficult to incorporate such clauses into smart contracts (Habib 2019; Bartoletti and Pompianu 2017; Yasini and Yasini 2019). Therefore, a mechanism to revoke or alter the original code in the event of restructuring or termination is essential. Marchesi et al. (2020), Feng et al. (2019), and Zulkepli et al. (2023) recommend the use of upgradable proxy contracts as a relevant initiative to address this emerging issue in smart contract coding method.

Security concerns are paramount, with coding errors potentially leading to code exploitation, as evidenced by the DAO case in 2016 (Duran and Griffin 2021; Nguyen et al. 2020; Sayeed et al. 2020). These errors, generic in nature, can also pose Shariah problems, particularly in *tawarruq* contracts when the contract's objective is not achieved. Therefore, the development of a robust control mechanism in smart contract creation is imperative. Marchesi et al. (2020) and Bartoletti and Pompianu recommend several precautions to ensure the security of smart contracts upon deployment in the blockchain.

CONCLUSION

The *tawarruq* contract stands as a cornerstone of Islamic banks' product offerings, albeit also carrying the highest recorded incidence of Shariah Non-Compliance (SNC) issues. As previously discussed, the adoption of blockchain-based

smart contracts holds the potential to effectively address SNC concerns within *tawarruq* contract operations. This is primarily due to its innate feature of automatic enforcement based on predefined terms without room for negligence, alongside the high transparency and security features inherent in blockchain technology. Nevertheless, the adoption of blockchain-based technology in Islamic banks' Shariah contracts, particularly *tawarruq* contracts, necessitates thorough consideration and management of associated risks, such as market and operational risks, to ensure alignment with the banks' operating environment and risk tolerance.

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AUTHORS' CONTRIBUTIONS

Muhammad Izzul Syahmi Zulkepli made significant contributions to the research by authoring the initial draft and carrying out analyses. Moreover, Mohammad Taqiuddin Mohamad, Saaidal Razalli Azzuhri, Mohd Shahid Mohd Noh, and Ahmed A. Jasim provided expert oversight, conceptualized ideas, and delivered thorough evaluations pertinent to the research topic. Their proficiency encompasses Shariah, Islamic banking operations, and smart contract blockchain-based mechanisms. All authors have reviewed and consented to the final manuscript for publication.

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