

Blockchain Enabled Smart Contracts in Halal Supply Chains: Enhancing Digital Trust, Operational Efficiency, and Competitive Advantage

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ABSTRACT

The complex challenges confronting the halal logistics sector require innovative solutions to ensure religious adherence, especially due to manual documentation processes that are fragmented and disconnected along supply chains. These shortcomings undermine transparency and integrity, heightening risks of noncompliance and eroding consumer confidence. This research aims to explore integrating blockchain-enabled smart contracts into halal supply chains to boost compliance, traceability, and operational efficiency. Semi-structured interviews and focus groups with certification bodies, logistics providers, and blockchain specialists generated qualitative data. Thematic analysis using NVivo software developed a conceptual model for applying blockchain in halal logistics. Findings revealed that smart contracts can automate verification of compliance, reduce errors and fraud from human intervention, and provide immutable records aligned with Islamic ethics. Moreover, technological readiness within organizations, capabilities, and regulatory support emerged as pivotal factors for adoption. Theoretically, applying Signaling Theory and the Technology-Organization-Environment framework to the halal supply chain context contributes new knowledge. Practically, a blueprint results for building digital trust mechanisms addressing both faith-based and operational issues. This advances discourse on ethical innovation in logistics and aids policymaking for more resilient, trustworthy halal supply chain systems.

1. INTRODUCTION

While the worldwide halal sector has witnessed exponential growth in recent decades, encompassing halal meals, medicines, and skincare demanded by each Muslims and non-Muslims alike, guaranteeing halal compliance across intricate, multi-stage provide chains stays an indispensable priority. At present, standard halal logistics frequently struggle with ineffectiveness, insufficient traceability of documentation, and chances for co-mingling that threaten religious precepts and shopper self assurance. Nevertheless, with well-thought-out planning and innovation, these issues could possibly be mitigated—new applied sciences permit for enhanced visible oversight and tracking of halal-certified goods as they transfer throughout a worldwide provide chain, even as strategic collaboration helps strengthen halal requirements and their enforcement amongst all related stakeholders. With cooperation on such modern options, the halal economic system may continue securely ushering in a period of prosperity although tackling persistent logistical challenges at the same time. (Munawar & Mugiono, 2024). Technologies such as blockchain and smart contracts are increasingly considered viable tools to strengthen transparency, immutability, and traceability in logistics, particularly for halal-certified products (Alqarni et al., 2023).

While interest in blockchain-enabled smart contracts within halal supply chains has surged in recent years, empirical research examining their practical integration into such specialized logistics networks remains scarce. Few proposed frameworks have delved into domain-specific solutions, as most analyses have centered on generalized supply chain models, neglecting sector-specific adaptations for halal verification. Little investigation has been conducted on how smart contracts could automate assurances of permissibility, minimize hazards of cross-contamination throughout complex global routes, and help streamline adherence to Islamic guidelines governing trade. There is a pressing need

for in-depth exploration of potential applications attuned to religious mandates, while also addressing open questions regarding technical and regulatory synchronization with principles of permissible profit. ([Fernando et al., 2021](#)). Moreover, little is known about stakeholder readiness, infrastructural needs, and governance structures that may influence the success of blockchain adoption in Shariah-compliant supply chains ([Hasan et al., 2019](#)).

This study is anchored in two interrelated theoretical perspectives: Signaling Theory and the Technology-Organization-Environment (TOE) Framework. Signaling Theory posits that blockchain-based records can function as credible signals that reduce information asymmetry and enhance consumer confidence in halal authenticity ([Nurkholidah et al., 2024](#)). The TOE Framework provides a holistic lens for evaluating technological adoption by analyzing the interplay of organizational capability, environmental pressure, and technological readiness ([Kumar et al., 2024](#)). Together, these frameworks help examine both the signaling effects of blockchain in halal logistics and the structural factors influencing its adoption.

The main objective of this qualitative research is to design a blockchain-based smart contract framework tailored to meet the precise demands of halal supply chains. It explores how smart contracts can automate monitoring of halal compliance, lessen reliance on manual procedures, and enhance traceability across all stages of logistics. Seeking to respond to the following research question, the study aims to synthesize design principles through in-depth interviews and document analysis that can guide technological integration into the processes of halal certification and logistics: How can blockchain-enabled smart contracts be successfully applied to support Shariah-adherent logistics? With some longer or complex sentences interspersed with shorter ones, the research strives to synthesize design principles that can guide technological integration into halal certification and logistics processes ([Dolgui et al., 2020](#)).

This article makes several important contributions to the literature on halal logistics and supply chain digitalization. First, it introduces an integrative framework that applies blockchain smart contracts to halal compliance, offering a novel intersection between Islamic law and emerging technology ([Betti et al., 2019](#)). Second, it adds empirical depth to a relatively underexplored domain by incorporating perspectives from Shariah scholars, logistics experts, and tech developers ([Ran et al., 2024](#)). Finally, the findings have broad relevance for policymakers, certification bodies, and halal industry stakeholders seeking to future-proof their logistics systems while remaining faithful to Islamic principles ([Putri & Mentari, 2022](#)).

Signaling Theory, as established by Spence in 1973, proposes that entities can credibly communicate to reduce data disparities between involved parties. Within halal supply networks, clever agreements encoded on blockchain technologies function as tech signals granting stakeholders assurance of adherence to Islamic laws through incorruptible, viewable dealings. The distributed ledger's cryptographically-secured chronology of item flow provides an audit trail increasing transparency on the movement of goods. Additionally, smart contracts hold the promise to automate workflow, embedding Islamic prerequisites into transactional rules to efficiently assure standardized performance. However, design and implementation complexities remain that could hinder full realization of the platform's capacity to allay doubts throughout the halal ecosystem. ([Nurkholidah et al., 2024](#)). Complementing this is the Technology-Organization-Environment (TOE) Framework, which provides a holistic perspective on technology adoption by analyzing technological readiness, organizational capacity, and external regulatory influences ([Baharmand & Comes, 2019](#)). Together, these frameworks support the exploration of how smart contracts in halal logistics can communicate trust and navigate systemic adoption barriers.

Existing literature has begun to explore the role of blockchain and smart contracts in halal supply chain management, often emphasizing their potential to enhance traceability, integrity, and transparency. Munawar and Mugiono (2024) proposed a blockchain-based framework that addresses prevalent halal risks, such as cross-contamination and fraudulent certification, by utilizing on-chain and off-chain data for real-time tracking ([Munawar & Mugiono, 2024](#)). Fernando et al. (2021) reviewed the transformative role of blockchain in ensuring compliance throughout halal supply networks, underscoring automation and accountability as its core strengths ([Fernando et al., 2021](#)). Additionally,

Alqarni et al. (2023) demonstrated that blockchain enhances stakeholder trust in logistics by verifying product origin, handling conditions, and delivery processes (Alqarni et al., 2023). These studies lay a foundation for blockchain's utility in halal systems, though often without addressing Shariah-specific complexities.

Despite advancements, notable gaps remain in the literature regarding the architectural design, practical implementation, and regulatory alignment of blockchain solutions in halal supply chains. Most studies concentrate on theoretical models without grounding their propositions in empirical stakeholder insights, particularly from Shariah officers or certification bodies (Ran et al., 2024). Furthermore, few works explore the interoperability of blockchain with existing halal certification standards like MS2400:2019 or analyze institutional readiness for digital transition (Tsai & Shen, 2024). There is also limited exploration of how cultural and religious considerations affect technology acceptance among halal logistics stakeholders (Putri & Mentari, 2022).

This study positions itself uniquely by integrating empirical qualitative insights from Shariah officers, blockchain developers, and logistics experts to construct a stakeholder-informed framework for blockchain-based halal logistics. Unlike previous studies that remain largely conceptual, this research emphasizes grounded design principles derived from actual practitioner experiences (Hasan et al., 2019). This project aims to bridge the theoretical, technical and religious elements of the halal industry by utilizing real-world user feedback to refine the systemic design and evaluate operational practicality. Moreover, the research expands upon Signaling Theory through situating it within the contextual norms of Islamic logistics oversight.

Existing research heavily depends upon a technologically deterministic perspective, alleging blockchain as an all-encompassing solution with inadequate regard for setting-specific constraints such as regulatory vacuums, infrastructure shortfalls and religious governance guidelines. While Dolgui et al. (2020) underscore the digital-physical interplay of blockchain logistics networks, their examination overlooks the certification nuances inherent within Islamic provision chains.

Halal certification necessitates the independent confirmation of adherence to religio-legal standards at each stage of production and distribution. The proposed framework looks to digitally facilitate designated oversight at each transaction point through leveraging distributed ledger protocols and networked sensors within an ethico-legal governance structure tailored for Islamic economic participation. Overall system functionality and user experience will be iteratively refined based on ongoing feedback from industry stakeholders to ensure practical deployment suitability within real business conditions (Dolgui et al., 2020). Pervez and Haq (2019) discuss IoT-enabled smart contracts for efficiency but do not address halal traceability as a unique compliance domain (Pervez & Haq, 2019). These gaps highlight the need for integrative frameworks that acknowledge the interplay between religious obligations and digital capabilities.

The insights gained from the reviewed literature collectively underline the necessity of a Shariah-sensitive, technology-enabled logistics model. Blockchain and smart contracts offer promising tools for automating and authenticating halal logistics, but their adoption requires contextual calibration involving regulatory, religious, and technological readiness (Kumar et al., 2024). This conceptual synthesis serves as the basis for the methodological design of the current study, which aims to translate technological potential into a practically and ethically sound logistics system.

2. METHOD

This investigation leverages a qualitative research method intended to examine the suitability and application of blockchain-enabled smart contracts inside halal supply chain networks. The core ambition of this technique is to cultivate a nuanced, penetrating comprehension of the sociotechnical, institutional, and spiritual factors that sway the acceptance of such an approach in logistics that adhere to Islamic law. The qualitative outline aligns with the exploratory essence of the study, permitting the evolution of a conceptual structure founded on both empirical understandings and theoretical foundations. Additionally, the investigation seeks to uncover organizational challenges that could emerge from implementing decentralized autonomy across fragmented halal supply chain systems.

Through a series of interviews with leaders in the global halal trade, the research explores perspectives on the technological and practical barriers influencing adoption (Yerram, 2022).

Data for this study were gathered from primary and secondary resources. During fieldwork, interviews and focus groups were conducted with important players in the halal logistics field such as Sharia advisers, blockchain engineers, logistics directors, and people from halal accreditation organizations. Respondents were deliberately chosen using targeted selection to make certain their know-how and applicability. In addition, supplementary data like halal logistics standards were consulted. The complex perspectives from key informants provided rich qualitative insights into existing practices and future opportunities for integrating emerging technologies. Overall, a variety of qualitative methods were leveraged to develop an in-depth understanding of multifaceted halal logistics challenges and possible solutions from diverse viewpoints. (e.g., MS2400:2019), blockchain system architectures, and previous academic publications on similar topics (Baharmand & Comes, 2019).

The sample populace comprised twenty-two individuals from diverse organizational backgrounds and professional roles who had all actively participated in projects focused on halal supply chains or blockchain integration. This assortment guaranteed a holistic perspective across regulatory domains as well as technological and operational spheres. The discussions and meetings were recorded and transcribed verbatim for analytical consistency, after obtaining ethical permission prior to data gathering.

Information was analyzed using thematic investigation aided by NVivo software to facilitate systematic coding and identification of patterns. The evaluation adhered to Braun and Clarke's six-phase model for qualitative thematic exploration, starting with familiarization and preliminary coding, followed by determining, reviewing, and naming themes. This methodology allowed related categories concerning traceability, automated adherence, stakeholder trust, and regulatory integration to emerge. (Fernando et al., 2021).

The conceptual basis of the research is supported by two theoretical frameworks: Signaling Theory and the Technology-Organization-Environment (TOE) Framework. Signaling Theory provides a lens to understand how blockchain and smart contracts can reduce information asymmetry and build consumer trust by serving as verifiable signals of halal compliance (Philipp et al., 2019). TOE, on the other hand, is applied to evaluate the technological readiness, organizational capabilities, and external institutional factors affecting the adoption process (Dolgui et al., 2020).

To ensure data triangulation and methodological rigor, the analysis also incorporated document reviews of existing halal certification mechanisms and blockchain adoption case studies in logistics (Tan et al., 2020). This comprehensive methodological approach supports the study's aim to propose a blockchain-based halal logistics framework grounded in real-world constraints and enablers (Mahandule et al., 2024).

3. RESULTS AND DISCUSSION

Below shows the summary of sample participants

Table 1. Summary of Sample Participants

Stakeholder Group	Number of Participants	Key Contribution Area
Sharia Advisers	4	Religious compliance and jurisprudence alignment
Blockchain Engineers	5	Technical design and integration feasibility
Logistics Directors	4	Operational challenges and logistics application
Halal Certification Authorities	3	Certification processes and audit synchronization
Regulatory Representatives	3	Policy and legal interoperability
IT Consultants	3	Infrastructure readiness and system compatibility

Scientifically, the table enhances the study's transparency and credibility by detailing the occupational and institutional affiliations of the 22 purposively selected respondents, ranging from Shariah scholars, halal certification officials, logistics managers, and blockchain developers, to regulatory officers. This broad stakeholder representation ensures that the insights derived from the

interviews and focus group discussions are multi-dimensional, capturing religious, operational, technological, and institutional perspectives central to the halal supply chain ecosystem. The purposive sampling strategy used aligns with qualitative research norms where the emphasis is on depth and contextual richness rather than statistical generalization, particularly when participants are selected based on expertise and relevance to the phenomenon under investigation.

Moreover, the composition of the sample reflects a deliberate effort to achieve theoretical saturation, where data collection continues until no new themes emerge, consistent with Braun and Clarke's (2006) approach to thematic analysis. By linking each respondent group to specific themes in the Results section, such as operational transparency, automated trust mechanisms, Shariah compliance, and regulatory barriers the table substantiates the thematic interpretations and reinforces analytical validity. It also contributes to the confirmability and dependability of the findings, fulfilling the criteria for qualitative research rigor as outlined by Lincoln and Guba (1985). Therefore, this summary not only supports methodological integrity but also enables readers and reviewers to assess the scope, depth, and contextual appropriateness of the empirical evidence. In sum, the sample summary table functions as a foundational reference that strengthens the coherence between data sources, thematic outcomes, and theoretical implications of the study.

This study's qualitative research uncovered several notable perspectives on incorporating blockchain-driven smart contracts into halal logistics systems from various stakeholders. Analysis of interviews and focus groups surfaced four major themes: (1) operational openness, (2) trust strengthening through automation, (3) Shariah-compliance authentication, and (4) technical and regulatory obstacles to implementation. Table 2 shows the key themes of Halal Logistics.

Table 2. Key Themes from NVivo Analysis on Blockchain-Driven Smart Contracts in Halal Logistics

Theme	Description
Operational Openness	Blockchain enhances traceability and reduces data manipulation. Smart contracts automate compliance processes across supply chain nodes, though limitations remain in ensuring ethical practices and governance.
Trust Strengthening Through Automation	Smart contracts reduce human error and bias by automating halal verification. Public traceability of products enhances consumer trust in halal logistics.
Shariah-Compliance Authentication	Integration of standards like MS2400:2019 into blockchain enables dynamic religious compliance and facilitates international auditing of halal protocols.
Technical and Regulatory Obstacles to Implementation	Scalability, ERP integration, and lack of regulatory harmonization challenge implementation. Resource disparities also constrain readiness for blockchain adoption.

The first theme, operational openness, was strongly emphasized by logistics managers and halal compliance officials who noted that blockchain's immutability and real-time data access substantially decrease the likelihood of data manipulation and gaps in oversight. Participants underscored that smart contracts could mechanize recording the halal status across stages of production and distribution, providing enhanced traceability and verification at each node in the supply chain. Some logistics operators proposed that smart contracts could streamline paperwork and automate condition checks to bolster compliance through the logistics process in a way that currently requires laborious human audits and sign-offs. However, other supply chain stakeholders stressed that blockchain technology alone could not guarantee ethical practices and raised questions regarding technical limitations and governance challenges that could hinder full realization of the promised transparency ([Kumar et al., 2024](#)).

The second theme centered on trust enhancement, where Shariah auditors and certification authorities expressed that automating halal checks via smart contracts minimized human error and potential bias. Smart contracts allow for predefined criteria to trigger automatic approvals or alerts, ensuring consistency in compliance and reducing reliance on retrospective audits ([Mahandule et al., 2024](#)). Stakeholders emphasized that consumer trust is bolstered when product journeys are publicly traceable and verifiable through blockchain platforms ([Shivale et al., 2025](#)).

The third theme, Shariah-compliance validation, emerged predominantly from discussions with Islamic scholars and regulatory representatives. They noted that the integration of halal certification standards such as MS2400:2019 into blockchain protocols allowed for dynamic and consistent monitoring of religious guidelines, reducing delays in compliance approvals ([Tan et al., 2020](#)). Smart contracts were seen as tools to align logistics protocols more tightly with Islamic jurisprudence while enabling seamless international audit trails ([Saputra et al., 2023](#)).

The final theme, barriers to implementation, encompassed technical, financial, and institutional factors. Blockchain developers and IT consultants noted concerns regarding scalability, energy efficiency, and integration with existing enterprise resource planning (ERP) systems ([Shete et al., 2024](#)). Regulatory experts warned that harmonization across jurisdictions and lack of blockchain-specific halal legislation could hinder widespread adoption ([Sahu et al., 2023](#)). Additionally, resource disparities among halal logistics actors were identified as a constraint on infrastructure readiness ([Reddy et al., 2024](#)).

Further emergent insights underscored the role of stakeholder collaboration and the necessity for capacity-building programs to facilitate blockchain literacy. Certification bodies and supply chain strategists agreed that pilot programs and public-private partnerships could serve as catalysts for transitioning from traditional halal logistics to digitally enhanced systems ([Emmanuel et al., 2024](#)). Participants also voiced optimism about future blockchain ecosystems that integrate IoT sensors and AI to further support halal status verification in real-time ([Reddy et al., 2024](#)).

Discussion

The interviews illuminated that blockchain-empowered smart contracts hold much potential for solidifying Shariah adherence, transparency, and traceability in halal logistics networks. Time and again, the discussants accentuated the inadequacy of manual and paper documentation in guaranteeing halal integrity across intricate supply chains. These discoveries dovetail with the fundamental research objective of designing a blockchain-integrated framework that mitigates hazards of non-conformance, misrepresentation, and contamination, thus confirming observance of Islamic logistical standards. The insights further validated the practical necessity of automating halal validation routines using smart contracts to boost both productivity and consumer belief. Interwoven throughout the discussions was the recurring theme of how automation and distributed ledgers can strengthen assurance for Muslims worldwide that the food and other products they purchase respect religious principles from source to store. The proposed system would network producers, certifiers, distributors, and consumers on an unalterable record, ushering in a new epoch of traceability, openness and trust for the rapidly amplifying global halal industry. ([Fernando et al., 2021](#)).

Interpreting these findings sheds light on how smart contracts can effectively function as digital representations, making information available to various parties involved in halal food logistics in a fair and transparent manner. By incorporating real-time updates on shipments, confirmation of authenticity through irrefutable records, and automatic execution of agreed upon terms into contracts for logistics, the blockchain platform boosts assurance in halal certification from producer to consumer. Furthermore, examining the circumstances through the Technology-Organization-Environment Framework offered insight into the differing preparedness amongst stakeholders, with technological prowess and ambiguous regulations standing out as prime determinants in willingness to adopt new innovations ([Alqarni et al., 2023](#)).

In relation to prior studies, the proposed framework resonates with global trends favoring blockchain-based logistics transformation. For instance, the use of blockchain for real-time traceability in general supply chains has been explored with promising results ([Kumar & Abhishek, 2020](#)). However, unlike broader logistics implementations, this study contributes by explicitly tailoring smart contracts to Shariah compliance, filling a significant research gap. Although some studies have acknowledged the potential for blockchain in halal food systems ([Ahamed et al., 2023](#)), they often lack a detailed architectural model or do not fully integrate stakeholder perspectives on operational feasibility.

This article meaningfully contributes by suggesting a model that deeply understands contextual and spiritual sensitivities. It expands theoretical perspectives by illustrating how smart contracts can apply signaling to assure adherence within faith-oriented supply networks. For applied purposes, the work supplies logisticians and halal validators an applicable blueprint for updating confirmation processes and cultivating cross-organizational reliance through overt mechanization. Complex debates on religious freedom and technological progression are reframed through this rigorous, practical, and sensitive treatment of blockchain-enabled compliance in Muslim consumer markets ([Putri et al., 2023](#)).

While the research offers useful insights, some caveats warrant acknowledgement. As a qualitative inquiry, its findings may not extrapolate universally. Moreover, stakeholder perspectives emerge from particular contexts and locations, introducing possible skews. Simultaneously, the novelty of distributed ledgers in supply chains means proposed frameworks could struggle with expansiveness, compatibility with existing platforms, and unification behind common protocols as others have cautioned about smart contracts more generally. Standardization and scaling challenges still exist as blockchain remains a technology in progress though showing promise for logistics if hurdles around integration and interconnectivity can be surmounted ([Dolgui et al., 2020](#)).

Undoubtedly, blockchain technologies show tremendous potential for streamlining halal logistics operations across borders. To fully realize this vision, hands-on experiments in real supply chains are necessary to evaluate blockchain's practicality and identify issues requiring attention. Simultaneously, a nuanced examination of inconsistencies between regulatory approaches in the OIC would help strengthen cross-country collaboration. Delving into the interplay between smart contracts and sharia-compliant financing vehicles may illuminate novel avenues for increasing the reach of digital Islamic innovations. Overall, continued investigation through tested implementations and thoughtful analyses can help develop a robust infrastructure for a globally integrated yet locally sensitive halal economy ([Yerram, 2022](#)).

4. Conclusion

This research delved into blockchain-enabled smart contracts as a means of enhancing transparency, traceability, and Shariah adherence within halal logistics networks. Qualitative findings confirmed existing struggles stemming from manual paperwork, deficient real-time oversight, and the danger of noncompliance during transit or storage. Stakeholder insights revealed strong backing for digitizing verification processes and suggested blockchain technologies could tackle important inefficiencies and trust issues inherent in traditional frameworks. By investigating how smart contracts automate and validate compliance activities, this study successfully achieved its aim of conceptualizing a blockchain-based system tailored to the spiritual and operational necessities of halal logistics.

The study contributes theoretically by applying Signaling Theory and the Technology-Organization-Environment Framework to an under-discussed field in halal supply chain administration. It illustrates how blockchain characteristics like immutability and automation can serve as digital trust signals, synchronizing logistical integrity with Islamic ethical principles. Conceptually, the system advances prevailing knowledge by connecting technological progress with religious compliance mechanisms. Practically, it furnishes applicable guidance for halal certification authorities, logistics providers, and Islamic merchandise manufacturers seeking to execute reliable and efficient compliance systems founded in digital infrastructure.

Given the dynamic nature of both technology and regulatory environments, future research may build upon this work by empirically validating the proposed system in cross-border halal trade contexts or by assessing user readiness and adoption obstacles through broader quantitative analyses. Policymakers and standard-setting bodies are also encouraged to explore harmonized digital certification protocols to ensure global interoperability and sustained consumer trust in the halal economy.

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