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Socio-technical trust in blockchain-based halal certification: an integrative governance framework

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ABSTRACT

The slow manual halal certification process in Indonesia and declining public trust in the Halal Product Assurance Agency pose crucial challenges. This study aims to systematically review the literature on digital transformation in halal certification bodies, focusing on the integration of blockchain technology, trust-building mechanisms, and governance challenges. Using the Systematic Literature Review (SLR) method guided by PRISMA, 32 peer-reviewed articles (2020–2025) were thematically analyzed. Key findings indicate that blockchain has the potential to improve transparency and efficiency. However, its success depends heavily on building socio-technical trust that combines technological reliability and institutional credibility as well as the ability to overcome governance barriers such as regulations and bureaucratic resistance. It concludes that effective digital transformation requires a holistic synergy between technological innovation, institutional reform, and public trust

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1. INTRODUCTION

As the world's most populous Muslim country, Indonesia faces significant challenges in implementing an effective, transparent, and reliable halal certification system. The mandatory halal certification for products entering, circulating, and trading in Indonesia, as mandated by Law No. 33 of 2014 concerning Halal Product Assurance, demands a fundamental transformation in public service governance (Pietersz et al., 2024). The current phenomenon shows that manual, bureaucratic, and undigitized processes are a major obstacle, especially for the millions of micro, Small, and Medium Enterprises (MSMEs), the backbone of the national economy. Data from the Ministry of Religious Affairs in 2024 indicated that more than 10 million MSMEs had not yet received halal certification, due to the process being perceived as complicated, time-consuming, and lacking widespread public awareness. This situation not only undermines public trust in the organizing body, the Halal Product Guarantee Agency, but also impacts the competitiveness of Indonesian halal products in the global market.(Cholil et al., 2025) (Rizkaprilisa et al., 2024)In this context, digital transformation through the adoption of disruptive technologies such as blockchain is beginning to be considered a strategic

solution to reform the halal certification ecosystem, increase efficiency, ensure traceability, and rebuild public trust. This issue is crucial because its implications extend beyond the domestic sphere and also impact Indonesia's position in the international halal supply chain and its vision to become a global hub for the halal industry.

Various studies confirm that blockchain technology has significant potential to revolutionize certification systems through its decentralization, immutability, and data transparency. In the halal industry, previous research consistently shows that blockchain can improve supply chain integrity, reduce the risk of certificate fraud, and ensure product authenticity. (Susanty, et al., 2023) (Azmar et al., 2025) However, most of this research still focuses on technical aspects and implementation in the industrial or corporate sectors, while studies on its integration within the context of public institutions, particularly state halal certification bodies, are still very limited. This research gap highlights the need for systematic analysis that not only highlights blockchain technology but also how it can play a role in establishing a more transparent and accountable digital governance system in public institutions such as Halal Product Guarantee Agency.

To strengthen the global relevance of this research, learning from other countries is crucial. Malaysia, for example, through the Department of Islamic Development Malaysia, has implemented an integrated digital certification system since 2019, emphasizing regulatory harmonization and standardization of procedures. (Alamsyah et al., 2022)The United Arab Emirates (UAE), through its "UAE Blockchain Strategy 2021," has also prioritized halal certification to increase transparency and trust through multi-stakeholder collaboration. (Alourani & Khan, 2025). In the UK, institutions such as the Halal Food Authority (HFA) and the Halal Monitoring Committee (HMC) have adopted information technology to enhance the credibility of certification, although they still face the challenge of fragmented standards. This international comparison demonstrates that successful digital transformation depends on regulatory consistency, collaboration between stakeholders, and strong institutional support. In the Indonesian context, the large economic scale and geographic and demographic diversity make the Halal Product Guarantee Agency challenges more complex, requiring an approach tailored to local needs while remaining aligned with global best practices.

To contextualize Indonesia’s position within the global halal certification landscape, a comparative perspective is necessary. Indonesia currently has approximately 65 million MSMEs, with more than 10 million business units remaining uncertified as of 2024. Under Law No. 33 of 2014, halal certification is mandatory for products entering and circulating in the domestic market. However, the system remains only partially digitized and continues to experience bureaucratic bottlenecks, regulatory complexity, and certification backlogs under the centralized authority of the Halal Product Guarantee Agency (BPJPH). This structural condition creates a scalability challenge that is fundamentally different from that faced by other countries.

In contrast, Malaysia, which has around 1.2 million SMEs, implements halal certification as mandatory for specific sectors and has successfully established a fully integrated digital system through the JAKIM e-Halal platform. The Malaysian model emphasizes regulatory harmonization and standardized procedures, resulting in a more streamlined administrative process and stronger institutional coherence. Meanwhile, the United Arab Emirates (UAE) positions halal certification within a broader national innovation strategy. Through the UAE Blockchain Strategy 2021, halal governance is embedded in a blockchain-driven ecosystem that promotes interoperability, multi-stakeholder collaboration, and innovation-oriented policy design. The UAE’s approach reflects a proactive integration of advanced technology with strategic governance reform.

The United Kingdom represents a different model altogether. Halal certification operates on a voluntary basis and is administered by private certification bodies such as the Halal Food Authority (HFA) and the Halal Monitoring Committee (HMC). Although

digital verification platforms are utilized, governance is market-driven and characterized by fragmented standards rather than centralized state authority. This structure reduces administrative pressure on the government but results in variability in certification legitimacy.

This comparative analysis demonstrates that Indonesia's halal certification challenge is not merely technological underdevelopment but rather a structural interaction between mandatory regulation, extremely large MSME volume, centralized governance authority, and institutional capacity constraints. Unlike Malaysia's harmonized digital bureaucracy, the UAE's innovation-led framework, or the UK's market-based system, Indonesia must manage large-scale mandatory compliance within a transitioning institutional environment. Consequently, digital transformation in Indonesia cannot be understood as simple digitization of procedures. Instead, it represents a complex governance reform process requiring synchronization between technological infrastructure, regulatory adaptation, and socio-institutional trust-building mechanisms.

Theoretically, this research is based on a multidisciplinary framework. The Technology Acceptance Model (TAM) and the Diffusion of Innovation Theory are used to analyze the factors influencing blockchain acceptance by stakeholders in the public sector.(Ly & Ly, 2024) (Bunlom & Sitheechoke, 2025). Institutional Theory provides a perspective for understanding how norms, external pressures, and regulations shape the digital transformation process in institutions such as Halal Product Guarantee Agency.(Gegenhuber, et al., 2022) Meanwhile, Trust Theory is the basis for assessing how digital mechanisms can build and maintain public trust in government services.(Gulati et al., 2024) (Isaeva et al., 2020) The synergy of these three theories allows for an in-depth exploration of the complex interactions between technology adoption, institutional structures, and the dynamics of public trust.

This research has significant academic and practical significance. Academically, this study fills a gap in the literature by presenting a systematic review of blockchain implementation in government halal certification governance, a topic that remains underexplored compared to its implementation in the private sector. The integration of various theories on technology, institutions, and trust provides a comprehensive analytical framework for understanding the complexities of digital transformation in public institutions with both regulatory and religious mandates. Practically, the results of this study are expected to provide evidence based strategic recommendations for Halal Product Guarantee Agency and the Ministry of Religious Affairs in designing a holistic digitalization strategy, encompassing not only technological aspects but also regulatory readiness, organizational capacity, and mechanisms for building public trust. Globally, this research supports Indonesia's efforts to strengthen its position in the international halal industry through a more reliable and widely recognized digital certification system.

Taking into account the background, research gaps, and urgency of the topic, this study aims to map, analyze, and synthesize the literature related to digital transformation in halal certification institutions. The main contribution of this study lies in the comprehensive integration of technology, trust, and governance aspects in the context of state-owned halal certification institutions. Unlike previous studies that have focused more on technical aspects or consumer behavior, this article explicitly highlights the socio-technical dynamics of trust in public institutions with religious legitimacy

2. RESEARCH METHOD

This study used the Systematic Literature Review (SLR) method to identify, evaluate, and synthesize literature related to digital transformation and blockchain integration in halal certification in Indonesia. The SLR procedure followed the PRISMA 2020 guidelines and Kitchenham guidelines to ensure an objective, transparent, and replicable review

process. A comprehensive literature search was conducted across eight reputable databases: Scopus, Web of Science, Science Direct, SpringerLink, IEEE Xplore, MDPI, Taylor & Francis, and Google Scholar using a combination of relevant keywords such as "Halal Certification, Blockchain, Digital Transformation, and Digital Governance. The publication range was limited to 2020–2025 and included only English and Indonesian-language articles. Article selection was carried out in stages through a process of identification, screening, eligibility assessment, and inclusion by applying inclusion criteria that included peer reviewed publications discussing technology integration, trust mechanisms, or governance in the halal ecosystem. Non-academic articles, studies without clear methodologies, and duplicate publications were excluded through exclusion criteria. The selected articles were then analyzed using thematic analysis, which allowed for the identification of patterns and grouping of findings into key themes related to blockchain integration models, trust mechanisms, and governance challenges in the digital transformation of halal certification in Indonesia.

To ensure transparency and replicability of the literature selection process, all stages of the Systematic Literature Review are visualized in the PRISMA 2020 flow diagram as shown in Figure 1. This diagram presents in detail the selection flow from the identification stage to the final inclusion, including the number of articles at each stage and the documented reasons for exclusion.

To enhance the clarity of the literature synthesis and facilitate readers' understanding of the characteristics of the reviewed studies, Table 1 presents a comprehensive summary of the 32 articles analyzed in this study. This table includes information on the authors, year of publication, country of study focus, research focus area, methods used, and key findings.

Table 1 shows that the reviewed studies cover a wide range of geographic contexts (with a predominance of Indonesian and global studies), research methods (qualitative, quantitative, conceptual, and literature reviews), and research focuses that encompass the three main pillars of this study: technology integration, trust mechanisms, and governance challenges. This diversity enriches the thematic analysis and ensures that the resulting synthesis is comprehensive and representative of the state-of-the-art literature in this field.

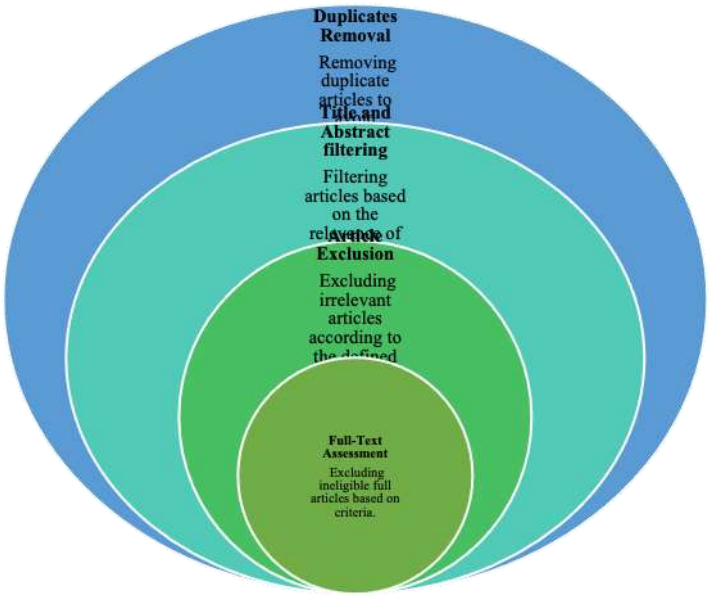

Figure 1. Article Selection Process
Source: Data Processed by Researchers, 2025

Table 1. Summary of Studies Analyzed in the Systematic Review

No	Author & Year	Country	Research Focus	Method	Key Findings
1	(Alamsyah et al., 2022)	Indonesia	Blockchain traceability in halal supply chains	Case study	Blockchain increases transparency and reduces certificate forgery
2	(Alourani & Khan, 2025)	UAE	Integration of AI and blockchain for halal traceability	Conceptual	Smart contracts automate sharia compliance verification
3	(Azmar et al., 2025)	Indonesia	Blockchain in the halal agri-food sector	Literature review	Blockchain opens up opportunities for innovation in the halal value chain
4	(Becker & Bodó, 2021)	Global	Trust in blockchain-based systems	Literature review	Trust is a socio-technical construct, not just a technological one.
5	(Bunlom & Sitheechoke, 2025)	Thailand	Strategic factors for blockchain adoption in the public sector	Quantitative	Leadership and regulatory support are key factors
6	(Bux et al., 2022)	Global	Sustainability of halal certification: blockchain vs certification	Literature review	Blockchain increases sustainability and transparency
7	(Charles et al., 2022)	Global	AI for decision making in the public sector	Literature review	Data governance and ethics are key challenges
8	(Cholil et al., 2025)	Indonesia	Economic benefits of halal certification in international trade	Literature review	Halal certification increases export competitiveness
9	(Effendi et al., 2023)	Indonesia	Transformation of halal awareness and blockchain in the halal value chain	Qualitative	Blockchain strengthens the integrity of the halal value chain
10	(Gegenhuber & Hinings, 2022a)	Global	Institutional logic and technological affordances in digital transformation	Conceptual	Digital transformation requires a change in institutional logic
11	(Gegenhuber & Hinings, 2022c)	Global	Institutional theory and digital transformation	Literature review	Institutional pressures shape the trajectory of digital transformation
12	(Gegenhuber & Hinings, 2022b)	Global	Institutional perspective of digital transformation	Literature review	Bureaucratic resistance is a major obstacle in the public sector
13	(Gulati et al., 2024)	Global	Trust models in human-computer interaction	Systematic literature review	Trust is built through transparency and consistency of the system
14	(Hu et al., 2023)	Global	IoT and subjective well-being of travelers	Quantitative	Digital technology increases trust through positive experiences
15	(Government, 2023)	Indonesia	Blockchain in government procurement of goods/services	Policy report	Blockchain reduces corruption and increases efficiency
16	(Isaeva et al., 2020)	Global	Trust theory in customer service	Literature review	Institutional trust is as important as technological trust
17	(Julian et al., 2025)	Indonesia	Integration of blockchain and AI in the halal supply chain	Conceptual	A trusted digital ecosystem requires synergy between technology and

No	Author & Year	Country	Research Focus	Method	Key Findings
					institutions.
18	(Ly & Ly, 2024)	Cambodia	Digital payment systems in developing economies	Quantitative	The diffusion of innovation theory explains the adoption of technology in developing countries.
19	(Mahsun, Effendi, et al., 2023)	Indonesia	Blockchain for halal information traceability	Case study	Blockchain increases accountability along the value chain
20	(Manzano Kharman & Sanders, 2024a)	Global	Governance vulnerabilities in Distributed Ledger Technologies	Conceptual	Poor governance reduces the effectiveness of blockchain
21	(Noor, 2024b)	Global	Technology Acceptance Model in the halal industry	Systematic literature review	Perceived usefulness and ease of use determine technology adoption
22	(Pangandaheng et al., 2022b)	Indonesia	Blockchain for halal certification	Systematic literature review	Blockchain is promising but requires clear regulation
23	(Pietersz et al., 2024b)	Indonesia	Mandatory halal certification as a barrier and promotion tool	Policy analysis	Halal certification can be a technical barrier to trade
24	(Indonesia, 2025)	Indonesia	Blockchain technology and regulatory challenges in local government	Case study	Limited human resources and regulations hamper implementation
25	(Reddick & Rodríguez-Bolívar, 2021)	Global	Blockchain in the public sector: theory and case studies	Literature review	Institutional reform is as important as technology adoption
26	(Rizkaprilisa et al., 2024)	Indonesia	Difficulties in the halal certification process	Qualitative	Manual, bureaucratic, and poorly socialized processes
27	(Shahaab et al., 2020)	Global	Trust in blockchain systems	Literature review	Technological trust must be complemented by institutional trust
28	(Sunmola et al., 2025)	Global	A holistic blockchain framework for halal compliance with AI	Conceptual	AI and blockchain create a robust compliance ecosystem
29	(Susanty, Effendi, et al., 2023)	Indonesia	Blockchain traceability application design for halal chicken meat supply chain	Case study	Blockchain reduces the risk of contamination and counterfeiting
30	(De Filippi & Wright, 2018b)	Global	Blockchain and the law: Rule of Code	Literature review	Blockchain challenges traditional regulatory paradigms
31	(Adinugraha et al., 2024)	Indonesia	Blockchain implementation for trust and transparency in the halal supply chain	Case study	Trust and transparency are the main outcomes of blockchain
32	(Pietersz et al., 2024a)	Indonesia	The potential of mandatory halal certification as a trade promotion tool	Policy analysis	Digitalization is needed to support halal exports

Source: Data Processed by Researchers, 2026

3. RESULTS AND DISCUSSIONS

Through the 2020 PRISMA-based Systematic Literature Review (SLR) process, of the 875 identified articles, only 32 studies met the criteria for analysis. These studies included 18 case studies, 10 literature reviews, and 4 conceptual articles published between 2020 and 2025. The thematic analysis yielded three core themes: (1) Blockchain Integration in Halal Certification, (2) Trust-Building Mechanisms in Digital Ecosystems, and (3) Challenges of Digital Governance in the Public Sector.

3.1. Integration Of Blockchain Technology In Halal Certification

The literature consistently identifies blockchain as a transformative infrastructure for halal certification governance. However, its significance extends beyond technical efficiency. Conceptually, blockchain introduces a structural shift from centralized bureaucratic verification to distributed trust architecture. Unlike conventional digitization—where paper-based processes are merely converted into electronic forms—blockchain redefines how authority, verification, and accountability are constructed within certification systems. As a distributed ledger technology, blockchain ensures immutability, traceability, and cryptographic validation across the halal supply chain (Alamsyah et al., 2022). Studies frequently highlight permissioned platforms such as Hyperledger Fabric, which allow regulatory bodies to control access while maintaining decentralized verification (Effendi et al., 2023). Yet, the theoretical relevance lies in how this architecture restructures governance logic. Instead of relying solely on institutional authority to validate halal compliance, blockchain embeds verification rules within code and consensus mechanisms (Mahsun et al., 2023; Alourani & Khan, 2025; Sunmola et al., 2025). This shift represents a movement from *trust in hierarchical oversight* toward *trust in socio-technical systems*.

From the perspective of the Technology Acceptance Model (TAM), transparency and automation increase perceived usefulness and ease of use (Noor, 2024). However, the theoretical implication is deeper: blockchain enhances perceived institutional reliability by reducing discretionary opacity. In contexts where bureaucratic inefficiency undermines confidence, technological transparency functions as a legitimacy-restoring mechanism. Similarly, Diffusion of Innovation Theory suggests that blockchain's relative advantage and compatibility with global halal traceability standards accelerate adoption. Yet, diffusion is not merely driven by technical superiority; it depends on alignment with institutional norms and regulatory frameworks (Julian et al., 2025). Therefore, blockchain adoption must be understood as a process of institutional embedding rather than technological substitution.

In the Indonesian context, where more than 10 million MSMEs remain uncertified due to procedural complexity and administrative bottlenecks, blockchain's relevance becomes structurally significant. The issue is not simply processing speed, but governance scalability. Traditional certification models rely on centralized verification capacity, which becomes strained under mandatory regulation and large MSME volumes. Blockchain, by contrast, distributes verification functions across network participants while maintaining regulatory oversight. This capacity for scalable verification addresses a core institutional limitation: the mismatch between regulatory ambition and administrative capability. Theoretically, this implies that blockchain in halal certification should be conceptualized not as a digital tool, but as a governance innovation that recalibrates the relationship between technology, institutional authority, and public trust. Its importance lies in its potential to transform certification from a bureaucratic compliance mechanism into a transparent, auditable, and trust-enabled ecosystem. Thus, blockchain integration represents a structural reconfiguration of halal governance rather than incremental process improvement.

3.2. Trust Formation Mechanisms In Digital Ecosystems

Literature shows that trust in blockchain systems does not emerge automatically, but is formed through a combination of technological mechanisms, institutions, and relationships between users (Shahaab et al., 2020). Trust in technology stems from the immutable, decentralized, and cryptographically secure nature of blockchain.(Nakamoto & Bitcoin.org, 2008)However, recent studies confirm that institutional trust, namely public confidence in Halal Product Guarantee Agency capacity to manage and oversee the system fairly and transparently, is equally important.(Becker & Bodó, 2021) The literature also emphasizes the importance of an easy-to-understand interface and effective public communication to ensure MSMEs and consumers feel confident and comfortable using the system.

These findings confirm that Halal Product Guarantee Agency blockchain implementation is a socio-technical project, not simply a technology one. While blockchain provides trust by design, the system's legitimacy still depends on credible governance. Successful digital transformation requires Halal Product Guarantee Agency to build institutional trust through clear participation rules, data protection standards, dispute resolution mechanisms, and transparent decision-making. Without a strong governance foundation, even the most sophisticated technology has the potential to be rejected due to perceived lack of accountability or bias.

This is highly relevant to Indonesia, where public trust in the BPJPH (Indonesian Halal Product Producing Agency) is declining due to a slow and opaque certification process. The current manual system requires people to rely on documents that are difficult to verify. Blockchain offers a fundamental shift by providing digital evidence that can be directly verified by consumers through QR codes that display the entire product history. For MSMEs, the transparency and predictability of the process increase confidence in participating in certification. With proper governance, blockchain can be a strategic tool for Halal Product Guarantee Agency to restore legitimacy, rebuild public trust, and strengthen the integrity of Indonesian halal certification at the national and global levels.

3.3. Challenges Of Digital Governance In The Public Sector

Literature shows that governance challenges are a major obstacle to public sector digital transformation, including blockchain implementation. These challenges include regulatory issues that are not yet ready to accommodate decentralized technology, bureaucratic resistance and limited interoperability with legacy systems, as well as low digital literacy and technical expertise among civil servants.(Indonesia, 2023) (Manzano Kharman & Sanders, 2024b) (Proceedings, 2025)These studies emphasize the need for strong leadership, strategic vision, and cross-stakeholder collaboration to address this complexity. Consequently, the success of Halal Product Guarantee Agency digital transformation is more of an institutional adaptation challenge than a technical one. Referring to Institutional Theory, technology will not be effective without internal reforms that include policy updates, strengthening human resource capacity, and establishing a more adaptive organizational culture. Good digital governance requires clear rules on data ownership, access rights, security standards, and audit mechanisms. Without a strong governance foundation, technology investments risk not delivering the expected results.

The governance challenges identified in the literature also reflect the current situation of Halal Product Guarantee Agency. The transition from a centralized certification system to a more distributed digital model requires significant changes in bureaucratic work patterns. Critical questions such as the legal status of digital halal certificates, smart contract error handling, and the involvement of MSMEs with low digital literacy indicate that the primary obstacle is governance, not technology. If left unaddressed, these obstacles will prevent Halal Product Guarantee Agency from

harnessing the full potential of blockchain. Therefore, Indonesia's success in building a global digital halal ecosystem depends heavily on its ability to create a credible, inclusive, and adaptive governance framework.

3.4. Discussion

This systematic review advances the argument that digital transformation in halal certification governance cannot be reduced to technological modernization. Instead, it represents a structural reconfiguration of how authority, verification, and legitimacy are constructed within public institutions. Three interrelated theoretical insights emerge from the synthesis.

First, blockchain integration constitutes a governance paradigm shift rather than a mere digitization effort. While prior studies emphasize traceability, transparency, and immutability, the theoretical implication lies in how these features redistribute verification authority from hierarchical bureaucratic control toward embedded technological validation. In this sense, blockchain functions as a legitimacy-producing infrastructure, reshaping the certification process from document-based compliance into system-based verification. This transition reframes halal certification as a digitally auditable ecosystem rather than an administratively controlled procedure.

Second, the success of blockchain adoption is mediated by socio-technical trust. Technological trust—derived from immutability and cryptographic reliability—is necessary but insufficient. Public sector digital transformation literature consistently shows that institutional trust remains decisive in determining acceptance. In the Indonesian context, where certification delays and bureaucratic opacity have weakened confidence, blockchain alone cannot restore legitimacy unless it is institutionally embedded within transparent governance structures. Thus, trust operates as a bridging construct that connects technological architecture to public legitimacy.

Third, governance emerges as the primary constraining variable. The central challenge is not technological feasibility but institutional adaptability. Regulatory ambiguity, bureaucratic resistance, and digital capability gaps reveal a structural misalignment between mandatory certification policy and administrative capacity. This confirms that digital transformation in public institutions is fundamentally an institutional reform process, where technology adoption must be synchronized with regulatory recalibration and organizational restructuring.

Collectively, these findings demonstrate that digital transformation within the Halal Product Guarantee Agency should be conceptualized as a triadic interaction between technology, socio-technical trust, and governance reform. None of these pillars operates independently; rather, their interaction determines transformation outcomes.

a. Integrative Conceptual Framework: A Digital Transformation Model Of Socio-Technical Trust-Based Halal Certification

Building upon these insights, this study proposes the Socio-Technical Trust Enabled Halal Certification Transformation (STHCT) Framework, presented in Figure X. The framework represents the study's primary theoretical contribution by integrating Technology Acceptance Model (TAM), Trust Theory, and Institutional Theory into a unified explanatory structure.

Unlike conventional digital transformation models that prioritize user adoption, or public governance frameworks that focus solely on bureaucratic reform, the STHCT framework conceptualizes socio-technical trust as a mediating mechanism between technological infrastructure and institutional legitimacy. By doing so, it extends existing models in three ways: (a) It moves beyond individual-level adoption logic (TAM) toward institutional-level legitimacy formation. (b) It reconceptualizes trust as structurally embedded within technological systems. (c) It positions governance reform as both an enabling and moderating force in digital transformation.

This integrative structure responds to the theoretical gap identified in the literature, where blockchain adoption, public trust, and institutional reform have largely been studied in isolation.

b. Explanation of the STHCT Conceptual Model

As illustrated in Figure X, the STHCT framework conceptualizes digital transformation as a recursive and non-linear system composed of three interdependent pillars:n(a) Technological Infrastructure,(b) Blockchain architecture, smart contracts, traceability systems), (b) Socio-Technical Trust, (Technological trust derived from system reliability and institutional trust derived from regulatory credibility), (c) Institutional Governance Reform, (Regulatory adaptation, bureaucratic restructuring, and digital capacity development)

The model proposes three core causal mechanisms: (a) Technological infrastructure generates technological trust through transparency and immutability. (b) Socio-technical trust enhances institutional legitimacy and stakeholder participation. (c) Governance reform reinforces technological implementation through regulatory clarity and capacity support.

Additionally, leadership and political support function as moderating variables, while feedback loops ensure that transformation outcomes—such as certification efficiency and increased public trust—recursively influence institutional and technological adaptation.

Unlike linear transformation models, the STHCT framework emphasizes that digital transformation in public halal certification is an iterative institutional learning process. Technology adoption strengthens trust; trust legitimizes reform; reform stabilizes technology. This cyclical interaction defines the sustainability of digital governance transformation.

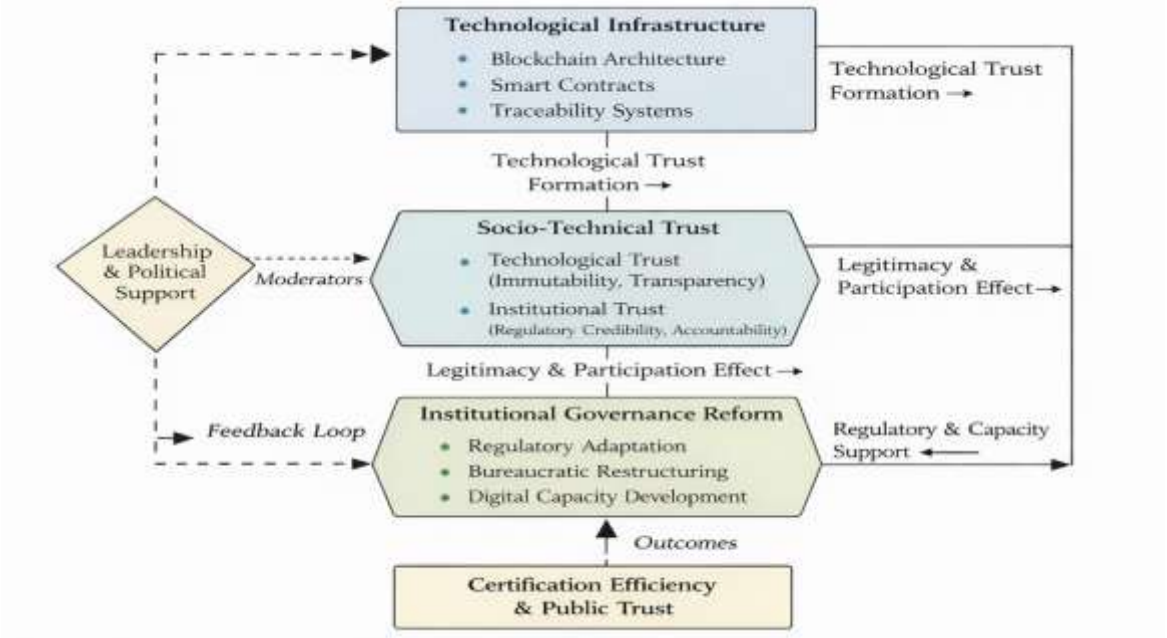

Figure 2. The Socio-Technical Trust Enabled Halal Certification Transformation (STHCT) Framework

c. Causal Mechanisms and Inter-Pillar Relationships:

The first causal mechanism explains how technological infrastructure influences socio-technical trust. Blockchain's core features—immutability, transparency, and traceability—reduce information asymmetry and limit discretionary manipulation in certification processes. These characteristics generate technological trust by embedding

verification within system architecture rather than relying solely on human oversight. However, technological reliability does not automatically translate into public legitimacy. In public sector governance, stakeholders evaluate both system integrity and institutional credibility. Therefore, technological trust must be institutionally anchored through accountable regulatory oversight and transparent administrative practices. Without institutional trust in the Halal Product Guarantee Agency as the system administrator, even a technically robust blockchain system risks skepticism or rejection. In this framework, socio-technical trust operates as a mediating mechanism that transforms technological capability into institutional legitimacy.

The second mechanism demonstrates how socio-technical trust influences governance reform. When stakeholders perceive both technological reliability and institutional accountability, resistance to institutional change decreases. Trust reduces uncertainty, increases compliance willingness among MSMEs, and strengthens the perceived fairness of regulatory adjustments. In this way, socio-technical trust reinforces governance reform by legitimizing regulatory adaptation, bureaucratic restructuring, and digital process standardization. Conversely, where trust is weak, governance reforms are more likely to be interpreted as administrative imposition rather than systemic improvement. Thus, trust functions not merely as an outcome of reform, but as a catalytic force that enables institutional transformation to proceed with broader stakeholder acceptance.

The third mechanism highlights how institutional governance reform conditions technological sustainability. Clear legal recognition of digital certificates, regulatory harmonization, interoperable data standards, and the development of digital competencies create the structural environment necessary for blockchain functionality. Without regulatory clarity and administrative capacity, technological adoption remains symbolic and fragmented. Institutional reform therefore acts as an enabling mechanism that stabilizes and legitimizes technological infrastructure. In this model, governance is not positioned as a passive consequence of technology adoption but as a co-determinant of its viability and long-term impact.

Leadership capacity, political commitment, and resource availability operate as moderating variables that strengthen or weaken these inter-pillar relationships. Strong political endorsement accelerates regulatory alignment, reduces bureaucratic inertia, and enhances institutional credibility. Conversely, fragmented authority structures or insufficient digital capacity may weaken the trust-building and governance-enabling effects of technological implementation. These moderators influence the intensity and speed of transformation rather than its structural direction. Finally, digital transformation is conceptualized as an iterative institutional learning process rather than a linear progression. Improvements in certification efficiency and public trust generate feedback that reinforces technological refinement and regulatory adjustment. Similarly, implementation challenges trigger adaptive governance responses. Through these recursive feedback loops, technology, trust, and governance co-evolve. This cyclical interaction distinguishes the STHCT framework from conventional linear digital transformation models and underscores that sustainable reform in halal certification governance depends on the continuous alignment of technological infrastructure, socio-technical trust, and institutional adaptation.

4. CONCLUSION

This study moves beyond describing blockchain adoption in halal certification and instead reconceptualizes digital transformation in public religious governance as a problem of institutional alignment. The findings demonstrate that technological innovation alone does not generate systemic reform. Rather, transformation emerges from the structured interaction between technological infrastructure, socio-technical

trust, and governance adaptation. By proposing the STHCT framework, this study advances a causal explanation of how these elements co-evolve and condition one another within mandatory certification regimes.

Theoretically, this research contributes to digital governance literature in three ways. First, it reframes blockchain as a legitimacy-producing infrastructure rather than merely an efficiency-enhancing tool. Second, it positions socio-technical trust as a mediating construct that connects technological architecture to institutional reform, extending traditional trust models that treat trust as an outcome variable. Third, it integrates institutional theory into technology adoption discourse, demonstrating that public sector digital transformation must be understood as a governance scalability challenge rather than a user-acceptance issue alone. These contributions collectively extend existing digital transformation models by embedding technological adoption within institutional legitimacy dynamics.

Practically, the study indicates that policy strategies for halal certification reform should prioritize regulatory synchronization and institutional capacity before large-scale technological deployment. Specifically, three policy directions emerge: (1) formal legal recognition and standardization of blockchain-based halal certificates to eliminate regulatory ambiguity; (2) structured digital competency programs for certification officers and MSMEs to reduce implementation asymmetry; and (3) transparent communication mechanisms that explicitly link technological transparency with institutional accountability. Without these governance preconditions, blockchain risks becoming symbolic digitization rather than structural reform. This study is limited by its reliance on secondary literature and the absence of empirical implementation data from BPJPH or related institutions. Future research should empirically test the causal mechanisms proposed in the STHCT framework through field-based case studies, institutional comparative analysis, and quantitative assessment of trust formation and certification efficiency. Such empirical validation is necessary to refine the model and assess its applicability beyond the Indonesian context. Ultimately, the sustainability of Indonesia's halal digital transformation will depend not on the sophistication of its technology, but on the institutional capacity to embed that technology within credible, adaptive, and trust-generating governance structures.

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