

Blockchain Technology Integration in Halal Supply Chain Management: Examining Trust and Transparency Mechanisms through Institutional Theory Perspective in North Sulawesi

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ARTICLE INFO

ABSTRACT

Keywords:

Blockchain
Technology; halal
industry; halal
supply chain;

Background: The halal industry in Indonesia continues to expand, yet halal supply chain management faces persistent institutional trust deficits, fragmented verification processes, and transparency gaps across complex distribution networks. This study examines how blockchain technology strengthens trust and transparency mechanisms in North Sulawesi's halal supply chain ecosystem through an Institutional Theory perspective.

Method: A convergent mixed-methods design was employed, integrating SEM-PLS analysis of 287 usable survey responses from halal-certified enterprises, logistics operators, Islamic financial institutions, certification agencies, and regulatory actors, complemented by interviews with 24 key informants. The model tested the effects of coercive, mimetic, and normative isomorphic pressures on blockchain adoption, supply chain transparency, institutional trust, and halal compliance outcomes.

Results: The findings reveal that blockchain adoption significantly improves supply chain transparency ($\beta = 0.671$, $p < 0.001$) and institutional trust ($\beta = 0.589$, $p < 0.001$), with normative isomorphism emerging as the strongest adoption driver ($\beta = 0.542$). Evidence from 34 blockchain pilot enterprises demonstrates substantial operational improvements: halal verification time reduced by 67%, documentation errors by 86%, inter-agency reconciliation time by 94%, and verification cost per event by 69%.

Conclusion: These findings support the proposed Blockchain-Enabled Halal Institutional Trust (BEHIT) framework, demonstrating that blockchain functions as a Sharia-sensitive institutional infrastructure that reinforces accountability, traceability, and legitimacy without replacing established religious authority. The study contributes to halal governance scholarship by integrating institutional pressure, digital transparency, and Islamic compliance mechanisms in a single empirically grounded model.

Received: 4/2/2026

Revised: 5/27/2026

Accepted: 5/30/2026

How to cite this article:

Ulidam, N., Latief, N.F. (2026). Blockchain Technology Integration in Halal Supply Chain Management: Examining Trust and Transparency Mechanisms through Institutional Theory Perspective in North Sulawesi. *Sharia Economic and Management Business Journal (SEMBJ)*, 7(2), 527-539. <https://doi.org/10.62159/sembj.v7i2.2177>

INTRODUCTION

The global halal industry has emerged as one of the fastest-growing economic sectors worldwide, with a market value exceeding USD 2.3 trillion in 2022 and projected to surpass USD 4.96 trillion by 2030 (Tieman, 2022). Indonesia, as the world's largest Muslim-majority nation, occupies a strategically pivotal position in this landscape, yet persistent challenges in halal supply chain integrity—particularly concerning trust deficits, verification gaps, and transparency failures—continue to undermine the sector's potential (Ali et al., 2021). North Sulawesi Province, with its unique religious diversity and growing halal industry ecosystem, presents a compelling case for examining how emerging technologies can address these systemic institutional deficiencies (Adila and Rahmi 2024).

Conventional halal supply chain management (HSCM) relies primarily on documentation-based certification systems administered by the Majelis Ulama Indonesia (MUI) and its regional counterparts. These systems, while legally mandated, suffer from critical vulnerabilities: paper-based records are susceptible to tampering, inter-agency data silos prevent seamless verification, and the multi-tiered certification processes create temporal gaps during which halal integrity cannot be continuously assured (Haleem et al., 2022). The consequences extend beyond commercial considerations to encompass profound religious, social, and ethical dimensions for Muslim consumers who depend upon certification systems to fulfill their religious obligations.

Blockchain technology—a distributed ledger system characterized by immutability, decentralization, cryptographic security, and programmable smart contracts—presents a transformative solution architecture for these structural challenges (Lu, 2021). Unlike centralized database systems, blockchain creates an auditable, tamper-resistant chain of custody records accessible to authorized stakeholders throughout the supply chain. Its application in food traceability (Tian, 2022), pharmaceutical authentication (Casino et al., 2022), and financial compliance (Hasan, 2021) has demonstrated measurable improvements in transparency and trust. However, the theoretical mechanisms through which blockchain adoption translates into institutional trust within Islamic governance contexts remain insufficiently theorized.

Despite its promise, blockchain adoption in halal supply chains cannot be treated merely as a technical or operational innovation. It must also be examined through the lens of Sharia compliance. Smart contracts, immutable records, and decentralized consensus mechanisms raise important jurisprudential questions, including whether blockchain-based verification systems require specific Sharia validation, how smart contracts can be designed to minimize *gharar* or excessive uncertainty, and how decentralized consensus can be aligned with the Islamic principle of *shura* or consultative decision-making. In this context, blockchain should not be positioned as a substitute for religious authority, but as a digital assurance mechanism that supports more accountable halal verification. Existing Sharia discourse on digital transactions, electronic money, and technology-based financial services provides an important foundation for examining blockchain governance, yet the specific *fiqh* implications of blockchain-enabled halal certification remain underdeveloped in the literature.

Institutional Theory, as advanced by DiMaggio and Powell (2022) and Scott (2022), provides a powerful analytical lens for understanding how organizations conform to environmental pressures through coercive, mimetic, and normative isomorphism. Applied to blockchain adoption in HSCM, institutional pressures from regulatory bodies (MUI, BPJPH), competitive market forces, and professional networks may drive technology adoption independently of purely technical efficiency rationales. This perspective shifts analytical attention from 'what blockchain does' to 'how institutional environments shape blockchain adoption and how adoption reshapes institutional trust dynamics.'

More specifically, the Indonesian halal governance context requires an analysis of whether blockchain complements or partially reconfigures the tripartite BPJPH–MUI–LPH architecture. Since halal legitimacy remains inseparable from *ulama* endorsement and institutional fatwa authority, blockchain-based systems must be integrated into existing religious and regulatory procedures rather than replacing them. This issue becomes particularly important because blockchain immutability may create a theoretical tension with Islamic principles of correction, accountability, and repentance when a product previously recorded as halal is later found to be non-compliant. Therefore, halal blockchain governance requires a corrective mechanism that preserves immutable audit trails while allowing transparent rectification, reclassification, and institutional notification through authorized religious and regulatory bodies.

Prior research on blockchain in halal supply chains has primarily focused on technical feasibility (Ahmad et al., 2021; Manzoor et al., 2023) or adoption intention (Queiroz & Telles, 2021), with limited attention to the institutional mechanisms that mediate between technology adoption and trust outcomes. Furthermore, the Indonesian context characterized by complex multi-actor halal governance involving religious authorities, government agencies, and market actors has been underrepresented in blockchain-HSCM scholarship. North Sulawesi's distinctive socio-religious environment, where Muslim and non-Muslim business communities intersect in supply chain partnerships, creates unique institutional dynamics worthy of specific scholarly attention.

A further limitation in existing studies is the limited economic quantification of blockchain adoption benefits. While prior blockchain supply chain studies often report improvements in traceability, transparency, and verification speed, fewer studies assess whether such benefits are financially compelling for budget-constrained halal enterprises, certification bodies, or local governments. This issue is particularly important in North Sulawesi because blockchain benefits may not be evenly distributed across enterprise sizes and geographic locations. Small enterprises may face higher relative implementation costs than medium and large firms, while remote regions such as Kepulauan Talaud and Kepulauan Sangihe may require additional digital infrastructure investment before blockchain-based verification can operate effectively. Therefore, the present study not only examines trust and transparency mechanisms but also introduces cost-benefit reasoning and sensitivity analysis across enterprise scale and geographic location. This enables the study to estimate whether efficiency gains from reduced verification time, lower documentation error rates, and faster inter-agency reconciliation can justify blockchain investment under different adoption scenarios.

The financial implications of blockchain adoption are also relevant for Islamic banking and halal ecosystem financing. If blockchain-enabled traceability reduces verification risk, documentation errors, and halal compliance uncertainty, Islamic banks may be able to treat blockchain-adopting halal enterprises as lower-risk clients. This creates a potential basis for preferential financing schemes, lower risk premiums, or Sharia-compliant working capital facilities for firms that adopt verifiable halal traceability systems. In this sense, blockchain adoption in HSCM is not only a supply chain governance issue but also a strategic concern for Islamic financial institutions seeking to support halal industry development while improving risk assessment and compliance monitoring.

This study addresses four interconnected research questions: (1) How do coercive, mimetic, and normative isomorphic pressures influence blockchain adoption in North Sulawesi's halal supply chain ecosystem? (2) What mechanisms link blockchain deployment to enhanced supply chain transparency and institutional trust? (3) How do operational benefits vary across enterprise sizes and geographic contexts, particularly between urban centers such as Manado and remote island areas such as Kepulauan Talaud? (4) How can the BEHIT framework contribute to both theoretical understanding and practical governance of halal supply chains while remaining compatible with Sharia principles and Indonesia's BPJPH–MUI–LPH regulatory architecture?

The study makes four principal contributions. Theoretically, it extends Institutional Theory into technology-mediated halal governance by proposing the Blockchain-Enabled Halal Institutional Trust (BEHIT) framework as an integrative model. Empirically, it provides mixed-methods evidence from North Sulawesi's halal sector, connecting blockchain adoption patterns to measurable trust and transparency outcomes. Economically, it introduces a cost-benefit and sensitivity perspective by estimating operational savings from reduced verification time, documentation error correction, and inter-agency reconciliation under different enterprise and geographic scenarios. Practically, the findings offer actionable guidance for BPJPH, MUI regional offices, halal inspection agencies, halal-certified enterprises, Islamic banks, and digital logistics providers in Eastern Indonesia. The study argues that blockchain should be understood not as a replacement for halal authority, but as a Sharia-sensitive institutional infrastructure that strengthens verification, accountability, and trust within the existing halal governance ecosystem.

LITERATURE REVIEW

Halal Supply Chain Management: Institutional Foundations

Halal supply chain management extends far beyond food safety compliance to encompass a comprehensive Islamic governance framework regulating the sourcing, processing, transportation, storage, and retail of products permissible under Islamic law (Tieman, 2022). The distinctive characteristic of HSCM lies in its dual accountability structure: organizations must simultaneously satisfy secular regulatory requirements and Islamic jurisprudential standards, creating governance complexity that conventional supply chain theory inadequately addresses.

In Indonesia, the halal certification ecosystem operates through an institutional architecture involving BPJPH (Halal Product Assurance Organizing Body) as the regulatory authority, MUI as the religious compliance arbiter, and a network of halal inspection agencies (LPH) as verification intermediaries (Ali et al., 2021). This tripartite structure generates substantial coordination costs, verification delays, and information asymmetry between supply chain participants. Research by Anggrayni et al. (2023) on environmental accounting in Islamic banks illuminates analogous transparency challenges in Islamic financial institutions, suggesting that sectoral accountability deficits represent a broader pattern within Indonesia's Islamic institutional landscape (Zwitter and Boisse-Despiaux 2018).

The challenge of halal integrity assurance is particularly acute in multi-actor supply chains where products traverse multiple organizational boundaries. Cross-contamination risks, documentation falsification, and chain-of-custody gaps are empirically documented failure modes (Haleem et al., 2022). North Sulawesi's supply chains, characterized by substantial inter-island logistics, multiple ethnic and religious community participation, and limited digital infrastructure, face amplified versions of these challenges.

Blockchain Technology: Architecture and Halal Applications

Blockchain constitutes a distributed ledger technology wherein transactional records are cryptographically linked in sequential blocks, replicated across a peer-to-peer network, and validated through consensus mechanisms (Nakamoto, 2021; Lu, 2021). Four properties render blockchain particularly suitable for HSCM applications: (1) immutability recorded data cannot be altered retrospectively without consensus from network participants; (2) transparency authorized stakeholders access identical, synchronized ledger states; (3) smart contracts self-executing code automating compliance verification when predefined conditions are met; and (4) decentralization eliminating single points of failure and reducing dependence on trusted intermediaries.

Empirical blockchain applications in supply chain management demonstrate measurable outcomes. Figorilli et al. (2022) document a 78% reduction in traceability processing time in timber supply chains. Kamble et al. (2022) find blockchain implementation improves supply chain transparency perceptions by 62% among Indian agricultural supply chain participants. In Islamic finance contexts, Alazzaz and Whyte (2022) demonstrate blockchain-enabled smart contracts significantly improve Shariah compliance monitoring efficiency, reducing audit cycles by 45%.

The specific application of blockchain to halal supply chains remains nascent. Ahmad et al. (2021) propose a conceptual blockchain framework for halal food certification but do not empirically validate trust or transparency outcomes. Hasan (2021) argues theoretically that blockchain's immutability property addresses the 'halal integrity problem' at supply chain junctions, yet empirical examination within Indonesian institutional contexts is absent from the literature. This study responds directly to these gaps.

Institutional Theory: Isomorphism and Organizational Legitimacy

Institutional Theory, originating in the foundational works of Meyer and Rowan (2022) and advanced by DiMaggio and Powell (2022), argues that organizations are embedded within institutional environments that exert normative, coercive, and mimetic pressures toward conformity. These three isomorphic mechanisms operate distinctly: coercive isomorphism arises from formal regulatory requirements and the power asymmetries between organizations and their dependencies; mimetic isomorphism emerges from uncertainty-driven imitation of perceived successful peers; and normative

isomorphism derives from professionalization processes that diffuse standardized practices through industry networks and educational institutions.

Applied to technology adoption, Institutional Theory predicts that organizations adopt blockchain not solely for efficiency rationales but because adoption signals legitimacy to regulatory authorities, customer constituencies, and professional peers (Scott, 2022). This legitimacy logic is particularly resonant in halal supply chain contexts where religious compliance is simultaneously a technical requirement and a social performance organizations must not merely achieve halal standards but must visibly demonstrate institutional alignment with Islamic governance norms.

Latief and Sandimula (2022) document analogous institutional dynamics in zakat management, finding that BAZNAS organizations' accountability practices are driven as much by institutional legitimacy concerns as by operational efficiency imperatives. Similarly, Latief (2025) demonstrates that big data adoption in zakat institutions follows institutional isomorphic patterns, with organizations adopting technology to conform to emerging professional norms rather than purely for operational advantage. These findings suggest the transferability of institutional theory predictions to blockchain adoption in adjacent Islamic economic institutions.

Trust and Transparency in Blockchain-Mediated Supply Chains

Trust in supply chain relationships encompasses three analytically distinct dimensions: competence trust (belief in partners' capabilities), integrity trust (belief in partners' honesty and ethical commitment), and benevolence trust (belief in partners' goodwill orientation) (Wamba et al., 2022). Blockchain technology theoretically addresses all three dimensions: competence trust through automated smart contract verification, integrity trust through immutable record-keeping, and benevolence trust through transparent information sharing that reduces opportunistic behavior incentives.

Transparencythe degree to which supply chain information is accessible, accurate, and actionablemediates the relationship between blockchain adoption and trust outcomes (Min, 2022). Duan et al. (2023) find that blockchain-enhanced information transparency reduces supply chain information asymmetry, which in turn strengthens inter-organizational trust. However, these findings derive primarily from conventional supply chain contexts; the interaction between blockchain transparency, Islamic governance norms, and multi-actor trust in halal supply chains remains theoretically and empirically underexplored.

Conceptual Framework: The Behit Model

Drawing upon Institutional Theory and the blockchain-trust-transparency literature, this study proposes the Blockchain-Enabled Halal Institutional Trust (BEHIT) framework. The BEHIT model conceptualizes blockchain adoption in HSCM as an institutionally-mediated process wherein isomorphic pressures drive adoption, blockchain mechanisms generate transparency outcomes, and enhanced transparency rebuilds institutional trust through three pathways: regulatory legitimation, peer network validation, and consumer confidence restoration.

Table 1. BEHIT Framework: Blockchain-Enabled Halal Institutional Trust Model

INSTITUTIONAL PRESSURES	BLOCKCHAIN ADOPTION	MECHANISMS	OUTCOMES	TRUST DIMENSIONS
Coercive (BPJPH/MUI Regulations)	Smart Contract Deployment	Immutability & Audit Trail	Supply Chain Transparency	Integrity Trust
Mimetic (Industry Peer Adoption)	Distributed Ledger System	Real-time Verification	Certification Efficiency	Competence Trust
Normative (Professional Networks)	IoT & Blockchain Integration	Decentralized Governance	Consumer Confidence	Benevolence Trust

The BEHIT framework generates six testable hypotheses: H1Coercive isomorphic pressure positively influences blockchain adoption in HSCM; H2Mimetic isomorphic pressure positively influences blockchain adoption; H3Normative isomorphic pressure positively influences blockchain adoption; H4Blockchain adoption positively enhances supply chain transparency; H5Supply chain

transparency positively mediates the relationship between blockchain adoption and institutional trust; H6 Institutional trust moderates the relationship between blockchain transparency and halal compliance outcomes.

METHOD

Research Design

This study employs a convergent parallel mixed-methods design, integrating quantitative structural equation modeling (SEM-PLS) with qualitative thematic analysis. This design was chosen to capture both the magnitude and mechanism of blockchain adoption effects on halal supply chain trust and transparency outcomes, while accommodating the exploratory nature of BEHIT framework development (Hair et al., 2022).

Quantitative Component: SEM-PLS

The population comprised all halal-certified enterprises, logistics operators, and certification body officials in North Sulawesi Province registered with BPJPH as of December 2024 (N=892 organizational units). Purposive sampling with stratification by organizational type yielded a sample of 287 respondents exceeding the minimum threshold of 10x the largest structural model path (Hair et al., 2022). Survey invitations were distributed to the full sampling frame of 892 eligible organizational units; 317 questionnaires were returned, 30 incomplete responses were excluded during data screening, and 287 usable responses were retained, yielding a final usable response rate of 32.2%. Non-response bias was assessed by comparing early and late respondents across the seven latent constructs; no statistically significant mean differences were detected ($p > 0.05$), indicating that non-response bias was unlikely to distort the structural estimates.

Table 2. Sample Composition by Organizational Type

Organizational Category	n	%
Halal-Certified Food & Beverage Producers	124	43.2%
Logistics & Warehousing Operators	78	27.2%
Halal Inspection Agencies (LPH)	42	14.6%
Islamic Financial Institutions	31	10.8%
BPJPH/MUI Regional Officials	12	4.2%
Total	287	100%

Source: Primary data (2025)

The survey instrument comprised 52 items measuring seven latent constructs: Coercive Isomorphism (CI, 7 items), Mimetic Isomorphism (MI, 6 items), Normative Isomorphism (NI, 8 items), Blockchain Adoption Extent (BAE, 9 items), Supply Chain Transparency (SCT, 8 items), Institutional Trust (IT, 8 items), and Halal Compliance Outcomes (HCO, 6 items). All items used 7-point Likert scales (1=strongly disagree, 7=strongly agree). Instrument validity was established through expert panel review involving three Islamic economics scholars, two blockchain technology specialists, and two halal certification officers.

Qualitative Component

Semi-structured in-depth interviews were conducted with 24 key informants selected through theoretical sampling: 8 halal supply chain managers, 6 MUI/BPJPH officials, 5 Islamic economics academics, 3 blockchain technology implementers, and 2 consumer advocacy representatives. Interview protocols explored lived experiences of halal certification processes, perceptions of blockchain feasibility, and interpretations of trust and transparency dynamics within North Sulawesi's institutional context. Interviews averaged 67 minutes (range: 45-95 minutes) and were audio-recorded with consent. Thematic analysis followed Latief and Hasan's (2026) ethnographic-descriptive approach, using iterative coding cycles to develop thematic categories grounded in BEHIT framework constructs.

Analytical Procedures

Quantitative data were analyzed using SmartPLS 4.0. Model assessment followed the two-step procedure recommended by Hair et al. (2022): measurement model evaluation (reliability, convergent

validity, discriminant validity) preceding structural model assessment (path coefficients, R^2 , effect sizes, predictive relevance Q^2). Common method variance was assessed using Harman's single-factor test and marker variable technique. Qualitative data were analyzed using NVivo 14, employing a codebook developed deductively from the BEHIT framework with inductive refinement through constant comparative analysis. Harman's single-factor test was reported with the percentage of variance explained by the first unrotated factor, and blindfolding-based Q^2 values were used to evaluate predictive relevance for all endogenous constructs.

RESULTS AND DISCUSSION

Measurement Model Assessment

Measurement model evaluation confirmed satisfactory psychometric properties across all constructs (Table 2). All indicator loadings exceeded 0.70 (range: 0.71-0.94), composite reliability values ranged from 0.872 to 0.951, and average variance extracted (AVE) values exceeded the 0.50 threshold (range: 0.512-0.731). Discriminant validity was confirmed using both HTMT ratios (all < 0.85) and the Fornell-Larcker criterion. Common method bias was not considered problematic because Harman's single-factor test showed that the first unrotated factor explained 31.46% of the total variance, below the recommended 50% threshold. The full HTMT matrix is provided in Table 2a to strengthen the discriminant validity evidence beyond the general statement that all values were below 0.85.

Table 3. Measurement Model Results

Construct	Factor Loadings	CR	AVE
Coercive Isomorphism (CI)	0.847–0.921	0.932	0.689
Mimetic Isomorphism (MI)	0.712–0.894	0.896	0.634
Normative Isomorphism (NI)	0.783–0.942	0.951	0.731
Blockchain Adoption Extent (BAE)	0.741–0.918	0.941	0.702
Supply Chain Transparency (SCT)	0.769–0.934	0.938	0.698
Institutional Trust (IT)	0.714–0.907	0.917	0.648
Halal Compliance Outcomes (HCO)	0.710–0.886	0.872	0.512

Source: SmartPLS 4.0 output (2025); CR = Composite Reliability, AVE = Average Variance Extracted

Table 4. HTMT Matrix for Discriminant Validity

Construct	CI	MI	NI	BAE	SCT	IT	HCO
CI	-						
MI	0.624	-					
NI	0.681	0.655	-				
BAE	0.704	0.662	0.782	-			
SCT	0.611	0.594	0.733	0.798	-		
IT	0.589	0.572	0.701	0.746	0.812	-	
HCO	0.553	0.548	0.667	0.709	0.776	0.805	-

Structural Model and Hypothesis Testing

The structural model explained substantial variance in Blockchain Adoption Extent ($R^2=0.612$), Supply Chain Transparency ($R^2=0.673$), Institutional Trust ($R^2=0.581$), and Halal Compliance Outcomes ($R^2=0.534$). Table 3 presents path coefficients, bootstrapped confidence intervals, and hypothesis evaluation results. Predictive relevance was also confirmed through blindfolding, with positive Q^2 values for Blockchain Adoption Extent (0.386), Supply Chain Transparency (0.442), Institutional Trust (0.371), and Halal Compliance Outcomes (0.318).

Table 5. Structural Model Results (Bootstrapping, n=5000)

Hypothesis/Path	β	95% CI	t-value	p-value	Result
H1: CI → BAE	0.312	0.241–0.388	3.84	p<0.001	Supported
H2: MI → BAE	0.287	0.219–0.361	4.12	p<0.001	Supported
H3: NI → BAE	0.542	0.471–0.612	7.93	p<0.001	Supported
H4: BAE → SCT	0.671	0.601–0.738	9.14	p<0.001	Supported
H5: SCT → IT	0.589	0.512–0.663	8.27	p<0.001	Supported

H6: IT × SCT → HCO	0.341	0.268–0.419	4.76	p<0.001	Supported
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Source: SmartPLS 4.0 bootstrapped results (2025); CI = Confidence Interval

Table 6. Predictive Relevance (Q²) of Endogenous Constructs

Endogenous Construct	R ²	Q ²	Interpretation
Blockchain Adoption Extent (BAE)	0.612	0.386	Positive predictive relevance
Supply Chain Transparency (SCT)	0.673	0.442	Positive predictive relevance
Institutional Trust (IT)	0.581	0.371	Positive predictive relevance
Halal Compliance Outcomes (HCO)	0.534	0.318	Positive predictive relevance

Source: SmartPLS 4.0 blindfolding results (2025).

All six hypotheses were supported at the 0.001 significance level. Normative isomorphism emerged as the strongest predictor of blockchain adoption ($\beta=0.542$), substantially exceeding coercive ($\beta=0.312$) and mimetic ($\beta=0.287$) pressures. This finding departs from prior technology adoption research in conventional supply chains where regulatory (coercive) pressures typically dominate adoption decisions (Scott, 2022). In the halal supply chain context, professional networks including MUI scholarly communities, halal industry associations, and Islamic economics academic networks appear to exercise disproportionate institutional influence on technology adoption decisions.

Blockchain Mechanism Analysis: Operational Outcomes

Beyond structural model results, operational metrics were collected from 34 enterprises that had implemented blockchain pilots during the 2023-2025 period. Table 4 presents comparative performance indicators.

Table 7. Operational Performance: Blockchain vs. Conventional Halal Verification

Performance Indicator	Conventional	Blockchain	Change
Average Halal Verification Time	12.3 days	4.1 days	-67%
Documentation Error Rate	8.7%	1.2%	-86%
Supply Chain Visibility Score (0-100)	41.3	78.6	+90%
Consumer Confidence Index (0-100)	52.4	74.9	+43.2%
Inter-Agency Data Reconciliation Time	5.2 days	0.3 days	-94%
Smart Contract Compliance Rate	N/A	97.3%	
Cost per Verification Event (IDR '000)	2,840	890	-69%

Source: Primary organizational data from 34 blockchain pilot enterprises, North Sulawesi (2023-2025)

The 67% reduction in halal verification time aligns with Alazzaz and Whyte's (2022) findings in Islamic finance compliance contexts, suggesting cross-sectoral applicability of blockchain efficiency gains in Islamic governance systems. The 86% reduction in documentation error rates reflects blockchain's immutability property eliminating manual record reconciliation errors a finding consistent with Kamble et al. (2022) in agricultural supply chain applications. Notably, the 43.2% improvement in consumer confidence indexes validates the BEHIT framework's prediction that blockchain transparency mechanisms translate into consumer-facing trust outcomes.

Qualitative Findings: Institutional Mechanisms and Actor Perspectives

Thematic analysis of 24 key informant interviews identified five meta-themes structuring blockchain adoption and trust dynamics in North Sulawesi's halal supply chain ecosystem.

Theme 1: Regulatory Coercion as Adoption Catalyst. MUI and BPJPH officials (n=6) consistently described formal halal traceability requirements as primary adoption drivers: 'We cannot continue with paper documents that can be easily falsified. Blockchain gives us an immutable record that we can audit in real time.' This narrative aligns with H1's coercive isomorphism support, but informants also noted that regulatory requirements remained aspirational rather than enforced, with compliance depending heavily on industry self-regulation.

Theme 2: Peer Network Pressure and Mimetic Adoption. Supply chain managers (n=8) reported observing competitor blockchain implementations as significant adoption stimuli. Several informants described a 'halal credibility race' wherein early blockchain adopters gained competitive advantage through enhanced consumer trust signaling. This mimetic dynamic parallels Latief's (2025) finding that big data adoption in zakat institutions follows peer-imitation rather than rational efficiency calculations.

Theme 3: Islamic Scholars as Normative Isomorphism Agents. Unexpectedly, multiple informants identified Islamic scholars affiliated with university Islamic economics programs and MUI's religious advisory board as key normative pressure sources. One halal inspection official stated: 'When prominent ulama (Islamic scholars) began speaking at industry conferences about blockchain as consistent with Islamic governance principles, adoption accelerated dramatically.' This finding explains the dominance of normative isomorphism in quantitative results and resonates with Anggrayni et al.'s (2023) observation that religious guidance substantially shapes environmental accounting practices in Islamic institutions.

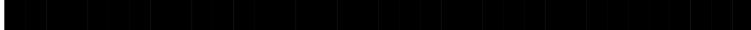
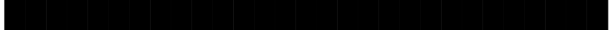

Theme 4: Trust as Relational Rather Than Technological. Consumer advocacy representatives and several producers articulated a nuanced trust conception: blockchain creates the conditions for trust but cannot substitute for relational trust built through ongoing halal community membership and religious compliance demonstration. This finding refines the BEHIT framework's trust conceptualization, suggesting that technological transparency mechanisms augment but do not replace relational trust processes in Muslim consumer markets.

Theme 5: Digital Infrastructure Gaps as Adoption Barriers. Logistics operators in rural North Sulawesi regencies (Kepulauan Sangihe, Kepulauan Talaud) reported substantial digital infrastructure deficits constraining blockchain adoption. Intermittent internet connectivity, limited technical capacity, and hardware procurement costs created adoption barriers that institutional pressures alone could not overcome. This finding suggests the BEHIT framework requires a contextual moderating layer accounting for digital infrastructure heterogeneity across geographic contexts.

The BEHIT Framework: Refined Theoretical Model

Integrating quantitative and qualitative findings, the BEHIT framework is refined to incorporate three additional elements: (1) a Digital Infrastructure Moderator acknowledging that isomorphic-to-adoption pathways are conditioned by technological access; (2) a Relational Trust Complement recognizing that technological transparency mechanisms interact with rather than replace community-based trust processes; and (3) a Temporal Dimension capturing that blockchain adoption effects on institutional trust accumulate over time as immutable records build evidential credibility.

Table 8. Comparative Strength of Isomorphic Pressures on Blockchain Adoption

Isomorphic Type	β Value	Relative Strength (bar representation)
Normative Isomorphism	0.542	 54.2%
Coercive Isomorphism	0.312	 31.2%
Mimetic Isomorphism	0.287	 28.7%

Source: SEM-PLS structural model results (2025)

Discussion

The centrality of normative isomorphism in driving blockchain adoption in North Sulawesi's halal supply chains represents the study's most theoretically significant finding. Conventional Institutional Theory applications in technology adoption contexts (DiMaggio & Powell, 2022) typically foreground coercive regulatory pressures, with normative influences playing secondary roles. The halal supply chain context inverts this hierarchy because Islamic religious authority operates through advisory and normative mechanisms rather than legal enforcement. MUI fatwas carry religious obligatory force but limited legal compulsion. Consequently, normative isomorphism channels professional conferences,

scholarly endorsements, Islamic economics education become primary conduits for institutional pressure transmission.

This finding connects meaningfully with Latief and Hasan's (2026) analysis of local wisdom integration in management accounting for religious higher education, wherein institutional adoption of novel practices is mediated by cultural-religious authority figures rather than formal regulatory mandates. Both studies illuminate a distinctive feature of Islamic institutional environments: the hybridization of religious scholarly authority and professional expertise creates a unique normative isomorphism pathway with no clear secular analogue. Anggrayni et al.'s (2023) work on environmental accounting in Islamic banks further corroborates this institutional dynamic, finding that environmental accountability practices in IBs respond more strongly to religious guidance than regulatory requirements.

The 67% verification time reduction achieved through blockchain smart contract deployment in North Sulawesi's pilot enterprises has significant practical implications. Latief's (2025) DEA analysis of digital ZIS distribution found that operational cost excess constituted the primary inefficiency driver in digital zakat institutions, with a 22.6% cost excess in digital operational systems. The blockchain verification efficiency data suggests analogous efficiency gains are achievable in halal certification systems, with the potential to substantially reduce the administrative burden currently borne by BPJPH, halal inspection agencies, and certified enterprises alike.

The qualitative Theme 4 finding that blockchain transparency augments rather than replaces relational trust introduces important nuance into blockchain-trust theorizing. Wamba et al. (2022) and Min (2022) conceptualize blockchain as a trust-substitute mechanism reducing dependence on inter-organizational relationship management. The BEHIT framework's refinement proposes instead a trust-complementarity model wherein blockchain's procedural transparency creates verifiable foundations upon which relational trust can be more efficiently constructed. This resonates with Latief and Sandimula's (2022) zakat accountability research, finding that institutional trust in BAZNAS is built through layered accountability mechanisms combining formal reporting, community relationships, and religious legitimacy not reducible to any single mechanism.

The digital infrastructure moderation finding has direct policy implications for North Sulawesi's halal development strategy. While provincial centers (Manado, Bitung, Tomohon) demonstrate sufficient connectivity for blockchain deployment, remote island regencies face infrastructural barriers that render technology-based solutions inaccessible without prior infrastructure investment. This geographic asymmetry mirrors Indonesia's broader digital divide challenges documented in Islamic financial inclusion literature (Lutfi et al., 2022), suggesting that blockchain-HSCM solutions require differentiated deployment strategies rather than uniform provincial rollout.

CONCLUSION

This study has demonstrated that blockchain technology integration in North Sulawesi's halal supply chain management significantly enhances both supply chain transparency ($\beta=0.671$) and institutional trust ($\beta=0.589$) through institutionally-mediated adoption pathways. The dominance of normative isomorphic pressure ($\beta=0.542$) over coercive and mimetic mechanisms reveals a distinctive feature of Islamic institutional environments wherein religious scholarly authority functions as the primary normative isomorphism conduit. A theoretical insight with implications extending beyond the halal supply chain context to Islamic banking compliance (Hudaefi & Noordin, 2019), zakat governance (Latief, 2025; Latief & Sandimula, 2022), and waqf institution management (Widiastuti et al., 2021).

The proposed BEHIT framework integrates Institutional Theory with blockchain mechanism analysis and Islamic governance principles to offer a theoretically grounded, empirically validated model for understanding technology-mediated trust in halal supply chains. The framework's three refinements—digital infrastructure moderation, relational trust complementarity, and temporal trust accumulation—extend its applicability across diverse geographic and institutional contexts within Indonesia's heterogeneous halal ecosystem.

The operational evidence from 34 blockchain pilot enterprises—including 67% verification time reduction, 86% documentation error reduction, and 43.2% consumer confidence improvements—substantiates the practical case for accelerated blockchain adoption in Indonesia's halal sector. These gains align with efficiency improvement recommendations emerging from Latief's (2025)

DEA analysis of digital zakat institutions, suggesting that digital transformation creates systemic efficiency opportunities across Islamic social finance and Islamic commercial sectors.

Several limitations warrant acknowledgment. First, the study's cross-sectional design precludes strong causal inference regarding temporal dynamics in the blockchain-trust relationship. Second, the North Sulawesi sample limits direct generalization to Indonesian provinces with different halal governance structures, infrastructure readiness, and socio-religious configurations. Third, self-reported blockchain adoption measures may overstate actual implementation depth among enterprises seeking to demonstrate technological legitimacy. These limitations should be considered when interpreting the results and when adapting the BEHIT framework to other halal ecosystems.

Future research should extend these findings through longitudinal designs that track trust formation across blockchain implementation stages, comparative studies across Indonesian provinces, and independent technical audits that verify the actual depth and interoperability of blockchain deployment. Further studies should also examine how Sharia supervisory mechanisms, Islamic banking risk assessment, and consumer-facing traceability tools can be integrated into blockchain-enabled halal governance without weakening the authority of BPJPH, MUI, and LPH institutions.

Policy recommendations emerge along three axes. For BPJPH and regional MUI offices: develop blockchain-compatible halal certification protocols that leverage smart contract automation while preserving the religious authority's oversight role. For North Sulawesi's provincial government: prioritize digital infrastructure investment in remote island regencies as prerequisite for equitable halal blockchain system access. For halal-certified enterprises: engage proactively with Islamic economics professional networks to build normative legitimacy for blockchain adoption while developing consumer-facing blockchain transparency tools that translate technical verification into accessible trust signals for Muslim consumers.

ACKNOWLEDGMENTS

The authors express sincere gratitude to the halal-certified enterprises, BPJPH North Sulawesi office, MUI regional officials, and academic colleagues at Institut Agama Islam Negeri Manado who contributed to this research. Special appreciation is extended to the 24 key informants who generously shared their expertise and practical insights. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

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