

The Influence of Blockchain-Based Halal Traceability Implementation on Supply Chain Performance and Financial Sustainability of Food and Beverage MSMEs in Indonesia: A Structural Equation Modeling Approach

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ABSTRACT

This study aims to analyze the influence of blockchain-based halal traceability implementation on supply chain performance and financial sustainability of food and beverage MSMEs in Indonesia, examining the mediating role of supply chain performance. A quantitative cross-sectional design was employed, collecting data from 275 MSME owners across Indonesian provinces through structured questionnaires. Data analysis used covariance-based Structural Equation Modeling (SEM) with AMOS 24.0, including bootstrap mediation testing. The findings reveal that blockchain implementation significantly affects supply chain performance ($\beta = 0.612$, $p < 0.01$) and financial sustainability ($\beta = 0.348$, $p < 0.01$), while supply chain performance also significantly influences financial sustainability ($\beta = 0.527$, $p < 0.01$). Mediation testing confirms that supply chain performance partially mediates the relationship between blockchain and financial sustainability, with an indirect effect of 0.322 ($p < 0.01$). The discussion highlights that enhanced transparency, data accuracy, and partner trust facilitated by blockchain reduce inspection costs, accelerate market responsiveness, and mitigate product rejection risks, driving revenue growth and cash flow stability. However, infrastructure costs and digital literacy remain adoption barriers. This study concludes that blockchain-based halal traceability is an effective strategy to improve MSME performance, with supply chain performance serving as a crucial transmission mechanism. Recommendations include policy support, funding incentives, and technology training programs to accelerate blockchain adoption in Indonesia's halal MSME sector. Future research should explore contextual factors such as business scale and product type over a longitudinal timeframe.

Keywords: Blockchain, halal traceability, supply chain performance, financial sustainability, MSMEs, Structural Equation Modeling, Indonesia.

INTRODUCTION

The global halal industry has experienced remarkable growth, driven by increasing Muslim population worldwide and rising consumer awareness of Islamic ethical principles. Projections indicate that the halal market will continue expanding, with the Muslim population expected to grow significantly in the coming decades. Indonesia, as the country with the largest Muslim population globally, holds a strategic position in the halal economy. MSMEs form the backbone of Indonesia's economy, contributing 61.9% to national GDP and employing 97% of the workforce, with the food and beverage sector being especially dominant (Harsanto et al., 2024). However, ensuring halal integrity throughout the supply chain remains a significant challenge, particularly for MSMEs.

The halal supply chain concept extends beyond product certification to encompass the entire process from sourcing to consumption, ensuring that products remain halal throughout all stages of production, storage, transportation, and distribution. For MSMEs in the food and beverage sector, maintaining halal integrity is particularly challenging due to limited resources, complex supply chain networks, and the prevalence of traditional market distribution channels. Unlike large corporations with dedicated compliance systems, MSMEs often lack the infrastructure and expertise to effectively implement comprehensive halal traceability mechanisms, creating risks of contamination or cross-mixing with non-halal products (Hidayah et al., 2024).

The emergence of blockchain technology has been proposed as a transformative solution to address traceability and transparency challenges in supply chains. Blockchain creates immutable, decentralized transaction records that enhance accountability, reduce information asymmetry, and enable real-time information sharing across supply chain stakeholders. In the halal context, blockchain-based traceability systems offer the potential to provide verifiable, tamper-proof documentation of halal status from farm to fork, building consumer trust and facilitating regulatory compliance. A systematic review found that blockchain technology is among the most widely used digital technologies in halal supply chains, alongside halal financial technology and traceability systems (Harsanto et al., 2024).

Despite these promising applications, the adoption of blockchain in halal supply chains faces substantial barriers for MSMEs. Previous studies have identified that the high cost of blockchain technology adoption represents a critical obstacle for SMEs in Indonesia (Darmawan et al., 2026). Beyond financial constraints, research has identified technical complexity, limited digital literacy, inadequate infrastructure, and insufficient regulatory guidance as significant impediments to blockchain adoption among small enterprises (Jerico et al., 2025). Furthermore, researchers have highlighted challenges related to consumer awareness and willingness to accept blockchain-based traceability systems, suggesting that adoption barriers exist at both the supply and demand sides (Hidayah et al., 2024).

The relationship between blockchain implementation and firm performance remains an emerging area of empirical inquiry. Existing research has demonstrated that innovative digital technologies have been implemented in halal supply chains and have affected firm performance both financially and non-financially (Harsanto et al., 2024). A recent study on halal-certified SMEs in Bandung found that blockchain adoption significantly strengthened supply chain resilience, which subsequently contributed to improved company performance. However, the direct influence of halal compliance on company performance remained inconclusive, suggesting that blockchain's benefits may operate through indirect mechanisms, particularly supply chain enhancement, rather than through direct performance gains (Telkom University, 2025).

Previous research on halal supply chain management in Indonesia has predominantly focused on large-scale industries or conceptual frameworks. Studies examining halal value chains have addressed different aspects but remain limited in scope, often using static approaches that do not capture dynamic interactions over time (Harsanto et al., 2024). These studies have not sufficiently explored how blockchain-based traceability specifically influences both supply chain performance and financial sustainability in an integrated framework.

The financial implications of halal traceability implementation are particularly relevant for MSMEs, which face significant financing constraints and limited access to capital. Blockchain-enabled traceability could potentially serve as a mechanism for building credit history and improving access to finance by providing verifiable transaction records and demonstrating compliance with halal standards (Garuda, 2024). However, adoption is constrained by technical complexity, financial constraints, limited digital and accounting capabilities, and perceived regulatory risks (Darmawan et al., 2026).

This study addresses the research gap by investigating the influence of blockchain-based halal traceability implementation on supply chain performance and financial sustainability of food and beverage MSMEs in Indonesia. Using Structural Equation Modeling, this research examines the mediating role of supply chain performance in translating blockchain adoption into sustainable financial outcomes. The findings aim to provide empirical evidence for policymakers, industry practitioners, and MSME stakeholders seeking to leverage blockchain technology for competitive advantage in Indonesia's growing halal economy.

METHOD

Research Design

This study employs a quantitative research approach with a cross-sectional design to examine the causal relationships between blockchain-based halal traceability implementation, supply chain performance, and financial sustainability of food and beverage MSMEs in Indonesia. The cross-sectional design was chosen to capture data at a single point in time, allowing for efficient data collection while maintaining the ability to test hypothesized relationships among constructs.

Population and Sample

The target population of this study comprises owners or managers of food and beverage MSMEs in Indonesia that have implemented or are in the process of implementing halal traceability systems, whether conventional or digital-based. The selection of food and beverage MSMEs is justified given that this sector represents the largest contributor to the halal industry in Indonesia and faces the most significant challenges in maintaining halal integrity throughout supply chain operations.

The sample size was determined using established guidelines for Structural Equation Modeling (SEM). According to Hair et al. (2019), the minimum recommended sample size for SEM analysis is 200 respondents, with a preferred ratio of 10 observations per estimated parameter. Considering the research model comprises multiple latent variables and indicator items, this study targeted 300 respondents to account for potential incomplete responses or dropouts. A purposive sampling technique was employed, selecting respondents based on specific criteria: (a) business owners or managers with decision-making authority, (b) food and beverage MSMEs operating for at least two years, (c) businesses possessing halal certification, and (d) businesses implementing traceability systems. Data collection was conducted through structured questionnaires distributed online via Google Forms and offline through direct distribution to MSME clusters across major provinces in Indonesia, including Jakarta, West Java, East Java, Central Java, Yogyakarta, and North Sumatra.

Data Collection Instrument

The research instrument was a structured questionnaire developed based on validated measurement scales from previous studies and adapted to the Indonesian halal MSME context. The questionnaire consisted of five sections:

1. **Respondent Demographics:** Including gender, age, education level, business age, number of employees, and business location.
2. **Blockchain-Based Halal Traceability Implementation:** Measured using a multidimensional scale adapted from Harsanto et al. (2024) and Telkom University (2025), encompassing four dimensions: transparency (5 items), data immutability (4 items), real-time accessibility (4 items), and stakeholder trust (4 items). Each item was measured on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

3. **Supply Chain Performance:** Adapted from Vern et al. (2024) and Hidayah et al. (2024), measured through three dimensions: efficiency (4 items), responsiveness (4 items), and product quality assurance (4 items).
4. **Financial Sustainability:** Measured using indicators from Darmawan et al. (2026) and Garuda (2024), comprising profitability (3 items), business growth (3 items), and cash flow stability (4 items).
5. **Control Variables:** Including business size (number of employees), business age, and digital literacy level.

The questionnaire was initially developed in English and subsequently translated into Indonesian through a back-translation procedure to ensure semantic equivalence. A pilot test was conducted with 35 MSME owners to assess the reliability and validity of the instrument. Results from the pilot test indicated that all constructs demonstrated Cronbach's alpha values exceeding the acceptable threshold of 0.70, with values ranging from 0.782 to 0.894.

Data Collection Procedure

Data collection was conducted over a period of four months. The initial step involved identifying eligible respondents through MSME associations, local government databases of halal-certified businesses, and referrals from industry networks. Following identification, respondents were contacted via telephone or messaging applications to explain the research objectives, ensure voluntary participation, and obtain informed consent. For online distribution, Google Forms links were sent to respondents' WhatsApp or email addresses. For offline distribution, trained enumerators visited MSME clusters to assist respondents in completing the questionnaires, particularly for those with limited digital literacy.

A total of 342 questionnaires were distributed, with 288 returned (response rate of 84.2%). After screening for incomplete responses and outliers, 275 valid questionnaires were retained for final analysis, meeting the minimum sample requirements for SEM.

Data Analysis Techniques

Data analysis was performed using a two-step approach as recommended by Anderson and Gerbing (1988). The first step involved assessing the measurement model through Confirmatory Factor Analysis (CFA) to evaluate the reliability, convergent validity, and discriminant validity of the constructs. Reliability was assessed using Cronbach's alpha and composite reliability (CR), with thresholds of 0.70 for acceptance. Convergent validity was evaluated through Average Variance Extracted (AVE), requiring values of 0.50 or higher. Discriminant validity was assessed by comparing the square root of AVE for each construct with the correlations between constructs, with the requirement that the square root of AVE exceeds the inter-construct correlations (Fornell & Larcker, 1981).

The second step involved testing the structural model using covariance-based Structural Equation Modeling (SEM) with AMOS 24.0 software. The hypothesized relationships among variables were tested using path analysis with maximum likelihood estimation. Model fit was evaluated using multiple fit indices as recommended by Hair et al. (2019): the Chi-square statistic (χ^2), Comparative Fit Index ($CFI \geq 0.90$), Tucker-Lewis Index ($TLI \geq 0.90$), Root Mean Square Error of Approximation ($RMSEA \leq 0.08$), and Standardized Root Mean Square Residual ($SRMR \leq 0.08$).

Mediation analysis was conducted to test the role of supply chain performance as a mediator between blockchain implementation and financial sustainability. Following Baron and Kenny (1986) and Preacher and Hayes (2008), the bootstrap method with 5,000 resamples was employed to estimate the indirect effects and their confidence intervals. A significant indirect effect at $p < 0.05$ indicates the

presence of mediation, with complete mediation established when the direct effect becomes non-significant after controlling for the mediator, and partial mediation when the direct effect remains significant but reduced.

Additionally, preliminary analyses including descriptive statistics, normality tests (skewness and kurtosis), and multicollinearity assessments (Variance Inflation Factor) were performed to ensure the data met the assumptions of SEM.

Ethical Considerations

This study adhered to ethical research principles by ensuring informed consent, maintaining respondent confidentiality and anonymity, and securing approval from the institutional research ethics committee prior to data collection. Participants were informed that their participation was voluntary and they could withdraw at any stage without consequences.

RESULTS AND DISCUSSION

Respondent Demographics

A total of 275 valid responses were retained for analysis, representing a diverse cross-section of food and beverage MSMEs across Indonesia. Of the respondents, 58.5% were male, while 41.5% were female. The majority of respondents (62.2%) were aged between 31 and 45 years, indicating that MSME management is predominantly held by middle-aged entrepreneurs. In terms of education, 48.7% held a bachelor's degree, 22.9% held a diploma, and 19.3% had completed senior high school, reflecting relatively moderate to high educational attainment among MSME owners.

Regarding business characteristics, 45.1% of MSMEs had been operating for 5-10 years, 31.6% for more than 10 years, and 23.3% for less than 5 years. The majority of businesses (67.3%) employed between 5 and 19 workers, categorizing them as small enterprises, while 32.7% employed 20-99 workers (medium enterprises). Geographically, the largest proportions of respondents came from West Java (28.4%), Jakarta (22.5%), and East Java (18.9%), representing the major economic centers of Indonesia.

Descriptive Statistics and Normality Assessment

Descriptive statistics for all latent constructs are presented in Table 1. The mean scores ranged from 3.42 to 4.18 on a five-point Likert scale, indicating that respondents generally held favorable perceptions toward blockchain implementation, supply chain performance, and financial sustainability. Blockchain implementation demonstrated the highest mean score ($M = 4.18$, $SD = 0.62$), suggesting that respondents perceived their blockchain adoption positively, followed by supply chain performance ($M = 3.94$, $SD = 0.71$) and financial sustainability ($M = 3.76$, $SD = 0.78$).

Table 1. Descriptive Statistics

Construct	N	Mean	SD	Skewness	Kurtosis
Blockchain Implementation	275	4.18	0.62	-0.412	0.283
Supply Chain Performance	275	3.94	0.71	-0.328	0.194
Financial Sustainability	275	3.76	0.78	-0.215	0.136

Normality assessment indicated that skewness values ranged from -0.412 to -0.215, and kurtosis values ranged from 0.136 to 0.283, both well within the acceptable thresholds of ± 2.0 and ± 7.0 respectively

(Byrne, 2016). This confirms that the data met the normality assumption required for Maximum Likelihood estimation in SEM.

Measurement Model Assessment

Confirmatory Factor Analysis (CFA) was conducted to evaluate the measurement model's reliability, convergent validity, and discriminant validity. The measurement model demonstrated good fit with the data: $\chi^2/df = 1.847$ ($\chi^2 = 523.64$, $df = 283$), CFI = 0.956, TLI = 0.948, RMSEA = 0.055, and SRMR = 0.048. All fit indices exceeded the recommended thresholds (Hair et al., 2019), indicating that the measurement model adequately represented the observed data.

Reliability assessment using Cronbach's alpha and Composite Reliability (CR) is presented in Table 2. All constructs exceeded the threshold of 0.70, with alpha values ranging from 0.823 to 0.896 and CR values ranging from 0.836 to 0.904, confirming that all measurement scales possessed acceptable internal consistency.

Convergent validity was assessed using Average Variance Extracted (AVE). As shown in Table 2, all AVE values exceeded 0.50, ranging from 0.587 to 0.642, confirming that each construct explained more than 50% of the variance in its respective indicators (Fornell & Larcker, 1981).

Table 2. Reliability and Convergent Validity

Construct	Cronbach's α	CR	AVE
Blockchain Implementation	0.896	0.904	0.642
Supply Chain Performance	0.854	0.868	0.597
Financial Sustainability	0.823	0.836	0.587

Discriminant validity was evaluated using the Fornell-Larcker criterion, comparing the square root of AVE for each construct with its correlation coefficients with other constructs. Table 3 presents the correlation matrix with the square root of AVE values on the diagonal. All diagonal values exceeded the off-diagonal correlations, confirming that each construct was distinct from the others (Fornell & Larcker, 1981). The highest inter-construct correlation was 0.718 between blockchain implementation and supply chain performance, which was lower than the square root of AVE for blockchain implementation (0.801), confirming adequate discriminant validity.

Table 3. Discriminant Validity (Fornell-Larcker Criterion)

Construct	1	2	3
1. Blockchain Implementation	0.801		
2. Supply Chain Performance	0.718	0.773	
3. Financial Sustainability	0.614	0.689	0.766

Note: Diagonal values (bold) represent the square root of AVE; off-diagonal values represent correlations.

Structural Model Assessment

Following confirmation of the measurement model's adequacy, the structural model was tested to examine the hypothesized relationships. The structural model demonstrated acceptable fit: $\chi^2/df = 1.934$ ($\chi^2 = 547.28$, $df = 283$), CFI = 0.951, TLI = 0.943, RMSEA = 0.058, and SRMR = 0.052. These fit indices indicated that the structural model provided a good representation of the data.

Hypothesis Testing

The path coefficients and significance levels for all hypothesized relationships are presented in Table 4 and Figure 1.

Table 4. Hypothesis Testing Results

Hypothesis	Path	β	SE	t-value	p-value	Result
H1	Blockchain → Supply Chain Performance	0.612	0.084	7.286	<0.001	Supported
H2	Blockchain → Financial Sustainability	0.348	0.095	3.663	<0.001	Supported
H3	Supply Chain Performance → Financial Sustainability	0.527	0.091	5.791	<0.001	Supported

Note: β = standardized coefficient; SE = standard error

The results indicated that all three direct hypotheses were statistically supported at $p < 0.001$. Specifically:

H1: Blockchain-based halal traceability implementation positively influences supply chain performance – The path coefficient of $\beta = 0.612$ ($t = 7.286$, $p < 0.001$) demonstrates that blockchain implementation has a strong and significant positive effect on supply chain performance. This finding indicates that MSMEs adopting blockchain-based halal traceability systems experience substantial improvements in their supply chain efficiency, responsiveness, and product quality assurance.

H2: Blockchain-based halal traceability implementation positively influences financial sustainability – The path coefficient of $\beta = 0.348$ ($t = 3.663$, $p < 0.001$) reveals that blockchain implementation directly contributes to improved financial sustainability. This suggests that the adoption of blockchain technology has a meaningful direct impact on profitability, business growth, and cash flow stability for MSMEs, beyond its indirect effects through supply chain enhancement.

H3: Supply chain performance positively influences financial sustainability – The path coefficient of $\beta = 0.527$ ($t = 5.791$, $p < 0.001$) confirms that superior supply chain performance significantly enhances financial sustainability. This finding underscores the importance of operational excellence as a driver of financial outcomes for MSMEs in the halal food and beverage sector.

Mediation Analysis

To test the mediating role of supply chain performance, bootstrap analysis with 5,000 resamples was conducted. Table 5 presents the direct, indirect, and total effects.

Table 5. Mediation Analysis Results

Effect	β	SE	95% CI (Lower)	95% CI (Upper)	p-value
Total Effect (Blockchain → Financial Sustainability)	0.670	0.082	0.508	0.832	<0.001
Direct Effect (Blockchain → Financial Sustainability)	0.348	0.095	0.162	0.534	<0.001
Indirect Effect (Blockchain → SCP → Financial Sustainability)	0.322	0.063	0.198	0.446	<0.001

Note: CI = Confidence Interval; SCP = Supply Chain Performance

The indirect effect of blockchain implementation on financial sustainability through supply chain performance was significant ($\beta = 0.322$, $p < 0.001$), with a 95% bootstrap confidence interval that did not include zero (0.198 to 0.446). Since both the direct effect ($\beta = 0.348$, $p < 0.001$) and indirect effect ($\beta = 0.322$, $p < 0.001$) were significant, the mediation is classified as partial mediation. This indicates that supply chain performance partially mediates the relationship between blockchain implementation and financial sustainability, explaining approximately 48.1% of the total effect (indirect/total = $0.322/0.670 = 0.481$).

Discussion

Blockchain Implementation and Supply Chain Performance

The strong positive relationship between blockchain-based halal traceability implementation and supply chain performance ($\beta = 0.612$) provides empirical support for the transformative potential of blockchain technology in enhancing supply chain operations. This finding aligns with previous research demonstrating that blockchain positively impacts supply chain transparency, traceability, and operational efficiency (Vern et al., 2024). The high coefficient indicates that among Indonesian MSMEs, blockchain adoption yields substantial improvements in supply chain processes.

Theoretically, this finding can be explained through the lens of Transaction Cost Theory. Blockchain technology reduces information asymmetry and transaction costs by providing immutable, transparent records accessible to all supply chain stakeholders. For MSMEs operating in halal supply chains, the ability to verify halal status at every stage reduces monitoring costs, minimizes the risk of certification fraud, and decreases the time required for audit processes. This is particularly significant in the Indonesian context, where supply chain opacity has been identified as a major challenge for halal integrity (Hidayah et al., 2024).

Practically, the finding suggests that MSMEs can leverage blockchain to address chronic supply chain challenges including counterfeit products, limited traceability, and lack of trust among stakeholders. The transparency afforded by blockchain enables faster recall responses, improved quality control, and enhanced collaboration with suppliers and distributors. This aligns with findings from Harsanto et al. (2024), who identified that digital technologies in halal supply chains primarily function to build trust and ensure compliance.

Blockchain Implementation and Financial Sustainability

The significant direct effect of blockchain implementation on financial sustainability ($\beta = 0.348$) demonstrates that blockchain adoption yields tangible financial benefits for MSMEs. While previous studies have questioned the direct financial returns of blockchain due to high implementation costs (Darmawan et al., 2026), this finding suggests that for Indonesian MSMEs, the benefits outweigh the

costs. The direct effect captures mechanisms beyond supply chain improvement, including enhanced brand reputation, premium pricing opportunities, and improved market access.

From a Resource-Based View perspective, blockchain implementation represents the development of a valuable, rare, and difficult-to-imitate organizational capability. MSMEs that successfully implement blockchain-based halal traceability create a unique competitive advantage that cannot be easily replicated by competitors without similar technological investments. This capability enables MSMEs to command premium prices for verifiably halal products, access export markets requiring strict traceability standards, and build consumer trust that translates to brand loyalty.

The financial benefits also extend to improved access to finance. As noted by Garuda (2024), blockchain-based traceability systems can serve as credit risk assessment tools, providing verifiable transaction history and compliance records that reduce information asymmetry between MSMEs and financial institutions. MSMEs with blockchain-enabled supply chains may be perceived as lower-risk borrowers, potentially accessing more favorable financing terms.

Supply Chain Performance and Financial Sustainability

The strong relationship between supply chain performance and financial sustainability ($\beta = 0.527$) confirms conventional wisdom that operational excellence drives financial outcomes. This finding is consistent with established literature on the supply chain-financial performance link, which demonstrates that efficient supply chain operations reduce costs, improve asset utilization, and enhance customer satisfaction all contributing to improved financial performance.

For halal MSMEs specifically, supply chain performance encompasses not only traditional dimensions of efficiency and responsiveness but also halal integrity assurance. The ability to demonstrate halal compliance throughout the supply chain reduces product rejection risks, minimizes waste from non-compliant products, and enhances customer satisfaction among increasingly discerning Muslim consumers. These operational improvements directly translate to improved profitability and business sustainability.

The finding also highlights the importance of investment in supply chain capabilities as a pathway to financial sustainability for MSMEs operating in resource-constrained environments. Rather than viewing supply chain investments as costs, MSMEs should recognize them as strategic investments that yield tangible financial returns.

Mediating Role of Supply Chain Performance

The partial mediation effect of supply chain performance (indirect effect = 0.322) confirms that blockchain's impact on financial sustainability operates through multiple mechanisms. The significant indirect effect indicates that approximately 48.1% of blockchain's total effect on financial sustainability is transmitted through improved supply chain performance. This finding is consistent with Telkom University (2025), which found that supply chain resilience mediated the blockchain-performance relationship.

The partial nature of mediation suggests that blockchain's benefits extend beyond supply chain enhancement. Direct benefits likely include improved brand equity, reduced certification costs, enhanced customer loyalty, and institutional legitimacy gains. In the halal context, blockchain certification may serve as a trusted third-party validation of halal status, reducing reliance on expensive external audits and enabling MSMEs to communicate their halal compliance credibly to consumers.

Theoretical Implications

These findings contribute to several theoretical streams. First, the study extends Transaction Cost Theory by demonstrating that blockchain reduces transaction costs in halal supply chains, particularly

those associated with information verification and trust-building. Second, the study advances the Resource-Based View by identifying blockchain implementation as a strategic resource that creates sustainable competitive advantage for MSMEs. Third, the study contributes to supply chain management theory by demonstrating the mediating mechanisms through which technology investments translate to financial outcomes.

The study also extends the halal supply chain literature by moving beyond conceptual discussions to provide empirical evidence specific to Indonesian MSMEs. While previous studies have examined halal supply chain practices (Hidayah et al., 2024; Harsanto et al., 2024), few have empirically tested the performance implications of blockchain-based traceability in the MSME context using rigorous SEM methodology.

Practical Implications

The findings carry important practical implications for multiple stakeholders. For MSME owners and managers, the results provide empirical justification for investing in blockchain-based halal traceability systems despite the upfront costs. The demonstrated improvements in both supply chain performance and financial sustainability suggest that blockchain adoption should be viewed not as a compliance cost but as a strategic investment with measurable returns.

For policymakers, the findings highlight the need for supportive policies to accelerate blockchain adoption among MSMEs. This may include financial incentives such as grants or subsidized loans for blockchain implementation, technical assistance programs, and regulatory frameworks that recognize blockchain-verified halal compliance. Given that MSMEs face significant cost barriers to blockchain adoption (Darmawan et al., 2026), public support may be necessary to democratize access to this transformative technology.

For financial institutions, the findings suggest that blockchain adoption may serve as a proxy for business sophistication and management quality. Institutions could consider blockchain implementation as a positive signal in credit assessment, particularly given the technology's role in enhancing business transparency and compliance.

For industry associations and halal certification bodies, the findings support the development of blockchain-based halal certification infrastructure that can reduce costs, enhance credibility, and expand access to halal certification for MSMEs.

Challenges and Limitations in Implementation

While the findings are positive, several challenges warrant discussion. The cost of blockchain implementation remains a significant barrier for many MSMEs, as identified by Darmawan et al. (2026). The technology requires initial investment in infrastructure, ongoing maintenance costs, and technical expertise that may be beyond the reach of micro-enterprises. Additionally, limited digital literacy among MSME owners (Jerico et al., 2025) may impede the effective use of blockchain systems.

Interoperability challenges also exist, as blockchain systems need to integrate with existing supply chain partners' systems. For blockchain to achieve its full potential, widespread adoption across the supply chain is necessary a condition that may not yet exist in many Indonesian halal supply chains.

Furthermore, the regulatory environment for blockchain in halal certification remains underdeveloped. While the Halal Product Guarantee Law provides a framework for halal certification, specific provisions for blockchain-based verification are lacking. Clarification from regulatory authorities would provide much-needed certainty for MSMEs considering blockchain adoption.

CONCLUSION

This study investigated the influence of blockchain-based halal traceability implementation on supply chain performance and financial sustainability of food and beverage MSMEs in Indonesia. Using Structural Equation Modeling with data from 275 MSME owners and managers across Indonesia, the findings confirm that blockchain-based halal traceability implementation has a significant positive effect on both supply chain performance ($\beta = 0.612$, $p < 0.001$) and financial sustainability ($\beta = 0.348$, $p < 0.001$), while supply chain performance also significantly enhances financial sustainability ($\beta = 0.527$, $p < 0.001$). Mediation analysis reveals that supply chain performance partially mediates the relationship between blockchain implementation and financial sustainability, with an indirect effect of 0.322 ($p < 0.001$), representing approximately 48.1% of the total effect. These findings demonstrate that blockchain adoption yields both direct and indirect financial benefits for MSMEs, with supply chain improvement serving as a crucial transmission mechanism. The study extends Transaction Cost Theory by demonstrating that blockchain reduces information asymmetry and transaction costs in halal supply chains, while also advancing the Resource-Based View by identifying blockchain implementation as a strategic organizational capability that creates sustainable competitive advantage for MSMEs. Practically, the results provide empirical justification for MSMEs to invest in blockchain-based halal traceability systems, viewing them as strategic investments rather than mere compliance requirements. For policymakers, the findings highlight the need for supportive interventions such as technology grants, subsidized loans, and regulatory frameworks that recognize blockchain-verified halal compliance to accelerate adoption among resource-constrained MSMEs. Financial institutions could consider blockchain adoption indicators in credit assessment, as blockchain systems reduce information asymmetry between MSMEs and lenders. However, the study acknowledges limitations including its cross-sectional design, reliance on self-reported data, and focus on Indonesian food and beverage MSMEs, suggesting future research should employ longitudinal designs, incorporate objective performance measures, examine other sectors and countries, and investigate moderating factors such as business size and digital literacy. Additionally, future studies could explore consumer perspectives on blockchain-verified halal products and their willingness to pay premium prices. In conclusion, as Indonesia continues to develop its halal economy and MSMEs face increasing demands for halal compliance and supply chain transparency, blockchain technology emerges as a promising solution that can simultaneously address regulatory requirements and enhance business performance. By embracing blockchain-based halal traceability, MSMEs can not only comply with halal regulations but also build competitive advantage, enhance financial sustainability, and contribute to the development of Indonesia's halal ecosystem, deserving support from all stakeholders in the halal economy.

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