

AI-Augmented Halal Blockchain Integrated with A Qualitypreneur Framework to Enhance Consumer Trust in the Sustainable Halal Industry

Afifah Nabila Afdhalia¹

¹Sekolah Pascasarjana, Universitas Gadjah Mada Yogyakarta, Indonesia

Abstract. The sustainable halal industry increasingly requires technological innovations that ensure transparency, integrity, and continuous quality assurance across the Halal Supply Chain Management (HSCM). This study proposes an integrative conceptual model that merges AI-augmented halal blockchain with the Qualitypreneur framework to strengthen consumer trust in halal products. Blockchain provides immutable, traceable, and tamper-resistant records of halal processes, while artificial intelligence enhances anomaly detection, fraud prediction, real-time monitoring, and automated halal verification. Meanwhile, the Qualitypreneur perspective grounded in Total Quality Management (TQM) offers a normative foundation for continuous improvement, competency development, and consistent adherence to halal-tayyib principles. The integration of these components forms a transparency-based trust mechanism in which AI-driven analytics complement blockchain's reliability and strengthen Qualitypreneur's quality assurance orientation. This model demonstrates how digital technologies and quality-driven entrepreneurship collectively reinforce halal integrity and contribute to the sustainability, credibility, and competitiveness of the global halal industry.

Keywords: AI, Halal blockchain, Qualitypreneur, Consumer Trust, Sustainable Halal Industry

1 Introduction

The demand for halal products continues to show significant growth at the global level. This increase is driven not only by the expanding number of Muslim consumers but also by shifting lifestyle preferences worldwide that increasingly emphasize health, safety, and ethical considerations in product consumption. The market value of halal products is projected to reach US \$282 billion by 2025 and continues to grow as a strategic sector in the global economy (Utami et al., 2024). This development expands the challenges for the halal industry in maintaining product quality and halal integrity consistently throughout the supply chain.

The complexity of global supply chains increases the risks of halal contamination, certification fraud, discrepancies in standards across countries, and weak end-to-end product traceability. These conditions make a transparent, efficient, and integrity-preserving halal supply chain management system crucial for enhancing public trust in the halal industry, ensuring that halal integrity is maintained from raw materials to the final consumer product (Hassan, 2025). In the context of sharia-based management, the Tetrapreneur framework offers a halal entrepreneurship approach that emphasizes four pillars, including Qualitypreneur, which focuses on ensuring quality, safety, and the sustainability of business processes based on halal-tayyib principles (Devi & Fatimah, 2025). This approach provides a managerial perspective that positions quality as a core value in maintaining consumer trust within the halal industry.

Alongside this approach, advancements in digital technologies particularly Artificial Intelligence (AI) have begun to play a significant role in optimizing halal inspection processes, risk analysis, and quality assessment. AI has been utilized to detect anomalies, identify potential contamination, and predict risk points within the supply chain more accurately and rapidly through machine learning and data-driven analytics (Narayanan et al., 2024). Simultaneously, halal blockchain technology has emerged as an innovation that enables real-time data traceability and permanent recording through a decentralized ledger system (Azmar et al., 2024). The implementation of smart contracts in halal blockchain systems supports the automatic validation of halal certification, thereby enhancing transparency and accountability at every stage of the supply chain (Mehmood et al., 2024). Thus, the integration of AI and blockchain has the potential to become a key enabler in applying Qualitypreneur principles by improving quality control, responsiveness, and the accuracy of quality monitoring.

¹ Corresponding author: nabilaafdhalia@gmail.com
No Hp/WA: +6289628150529

However, the existing literature remains limited in discussing how the Tetrapreneur management approach particularly Qualitypreneur can collaborate with AI-supported halal blockchain technology to enhance consumer trust in the halal industry. Most previous studies only highlight the technical aspects of blockchain, supply chain efficiency, or the potential of AI separately, without moving toward a conceptual model that integrates sharia-based managerial values with technological innovation to reinforce halal integrity. Therefore, this study aims to formulate a theoretical framework that integrates AI-supported halal blockchain into halal supply chain management through the Qualitypreneur approach within the Tetrapreneur framework. The goal is to provide a more comprehensive understanding of efforts to enhance consumer trust in halal products holistically. Additionally, this study is expected to offer a new paradigm in quality perspectives based on sharia values, ensuring that the use of technology not only promotes greater transparency and quality assurance but also strengthens the trust and well-being of Muslim consumers in practicing a halal lifestyle.

2 . Literature Review

2.1 Management Halal Supply Chain

Halal supply chain management is a system designed to ensure that halal products maintain their integrity from the procurement of raw materials to distribution to end consumers by complying with sharia principles. The initial stage begins with the selection of raw material sources that must be free from haram elements such as pork, alcohol, and other ingredients that are not in accordance with Islamic law (Hidayat et al., 2024; Khoirunnisa et al., 2024). During the production stage, raw materials must be processed with strict attention to hygiene, avoiding cross-contamination, and following strict halal procedures. These efforts are crucial in maintaining consumer trust, especially among Muslim consumers who prioritize halal integrity in their purchasing decisions (Perdana, 2020).

The distribution and logistics stages also play a strategic role because product halalness must be maintained during storage, transportation, and final delivery (Anggara et al., 2024). Halal integrity involves not only physical aspects but also ethical dimensions, such as transparency, accountability, and fairness in supply chain management. The application of artificial intelligence (AI) further strengthens these ethical dimensions. AI has been utilized to optimize monitoring, predict risk points, and improve traceability automatically through data processing and machine learning, thereby strengthening companies' commitment to halal principles and increasing consumer trust (Rochim et al., 2024).

In addition to AI, halal blockchain technology has become a digital innovation that offers comprehensive solutions to the challenges of traceability and integrity in HSCM. Blockchain provides a decentralized digital recording system that is transparent, immutable, and verifiable by all interested parties. Through a permanent recording mechanism, every stage of the supply chain from raw material procurement, production, distribution, to final access by consumers can be traced in real time (Jha et al., 2024). Thus, blockchain not only ensures monitoring efficiency but also strengthens halal assurance in accordance with sharia principles, thereby increasing consumer confidence in the validity of halal claims on a product.

2.2 Qualitypreneur

Qualitypreneurs within the Tetrapreneur framework emphasize the application of quality in products, processes, and services as the basis for business sustainability (Fatimah, 2018). This approach focuses on improving service, managerial competence, and professionalism as the foundation of business quality (Rahmatika et al., 2019). In the context of the halal supply chain, Qualitypreneur requires quality control that is consistent with the principles of halal-tayyib, covering the physical aspects of products, documentation, audits, and traceability mechanisms.

The integration of modern technology further strengthens the implementation of Qualitypreneur. Artificial intelligence (AI) supports anomaly detection, contamination risk prediction, and data-based quality assessment, thereby accelerating and improving the accuracy of the audit process. This is in line with the need for responsive and sustainable halal supervision. On the other hand, halal blockchain technology provides decentralized, transparent, and immutable records, ensuring that every stage of the supply chain can be systematically verified. Thus, the use of AI and blockchain provides technical reinforcement of Qualitypreneur principles, enabling the implementation of halal quality standards in a more objective, accountable, and transparent manner. This collaboration ultimately increases consumer confidence in halal claims because product quality and integrity can be proven through valid and traceable data.

2.3 Theory of Planned Behavior

The Theory of Planned Behavior (TPB) explains that a person's intention to accept or use an innovation is influenced by three constructs: attitude, subjective norms, and perceived behavioral control (Barbera & Ajzen, 2020). In the application of Halal Blockchain in Halal Supply Chain Management, TPB is a relevant framework for understanding how consumer trust and intentions are formed. Previous research shows that positive attitudes toward blockchain, social influence, and perceived ease of use play an important role in shaping consumer intentions to adopt a blockchain-based halal certification system (Karyani et al., 2024). Another study on blockchain food traceability also found that attitude and perceived behavioral control have a significant influence on the intention to use this technology, while subjective norms do not always have a strong influence (Lin et al., 2021).

In the context of the latest technological developments, the integration of artificial intelligence (AI) into halal blockchain systems reinforces the relevance of TPB. AI features such as anomaly detection, predictive analytics, and automated verification can improve consumers' perception that this technology is easier to use, more accurate, and more trustworthy. As a result, AI indirectly improves consumer attitudes toward technology, expands subjective norms through the influence of industries and regulators that adopt AI-based systems, and strengthens perceived behavioral control because consumers feel that the system is increasingly practical, secure, and accessible.

3. Research Methods

This study uses a qualitative approach with a literature review method. All data used comes from secondary sources in the form of scientific journal articles, books, and academic publications relevant to the topics of Halal Blockchain, Artificial Intelligence (AI), Halal Supply Chain Management (HSCM), Qualitypreneur, and Consumer Trust. The literature was obtained through online databases such as journals, books, articles, academic publications, and regulations relevant to the topic with the main criteria being directly related to the research theme and published in reputable journals. The analysis was conducted using content analysis, which involved examining, classifying, and synthesizing findings from various literature to find connections between concepts. The results of this literature review were then used to develop a conceptual framework explaining how the integration of AI-supported halal blockchain technology in halal supply chain management can increase consumer trust through the Qualitypreneur approach.

4. Result

4.1 The Role of AI-Augmented Halal Blockchain in Strengthening Halal Integrity in Halal Supply Chain Management

Halal Supply Chain Management (HSCM) still faces a variety of fundamental issues that hinder its effectiveness and consistency in implementation. Several studies indicate that regulatory inconsistencies, limitations in traceability systems, and sustainability issues are the main obstacles that make HSCM integration difficult to align with global standards (Ghalih & Chang, 2025). Other challenges arise in the form of varying halal certification standards across regions, weak monitoring systems, and inadequate storage infrastructure to ensure that products remain halal throughout the distribution process (Adenan et al., 2025). Additionally, the absence of specific regulations regarding halal logistics, low awareness among stakeholders about halal practices, a lack of experts and researchers, as well as limited supporting facilities further undermine the effectiveness of HSCM implementation (Rizki et al., 2023). Limited access to modern technology and insufficient training for human resources are also factors that weaken the industry's ability to maintain halal integrity consistently (Wahyuni & Pudjowati, 2024). Meanwhile, fragmented regulations, minimal operational standards, inadequate infrastructure, and high costs of certification and special facilities add burdens to industry players in conducting halal-compliant logistics, which ultimately affects consumer trust in halal products (Mazuki, 2025).

Halal supply chains have several vulnerabilities that can compromise product halal integrity, particularly related to the risks of cross-contamination, fraud, and weak traceability systems. Cross-contamination can occur when halal products are mixed with non-halal products during production, storage, or distribution, inadvertently resulting in counterfeit halal products (Voak, 2021). This risk increases when physical separation is not properly implemented, transportation facilities are shared, or supervision of containers and equipment is inconsistent. Fraudulent practices in the halal supply chain can manifest as mislabeling or misrepresentation of materials, including incorrect halal labeling on raw materials or packaging, which ultimately erodes consumer confidence in product authenticity (Masudin et al., 2025).

On the other hand, weaknesses in traceability systems add complexity to the problem, as limited visibility of distribution flows and supplier information makes it difficult to accurately verify product origins (Kamarulzaman

& Tarmizi, 2020; Voak, 2021). The inability of tracking systems to provide comprehensive evidence regarding the journey of halal products throughout the supply chain creates difficulties in ensuring compliance with halal standards and hinders efforts to maintain the reliability and credibility of the halal industry. These vulnerabilities underscore the need for technological solutions capable of providing transparency and end-to-end control.

The utilization of blockchain technology in the halal supply chain offers a mechanism capable of overcoming the weaknesses of conventional systems, particularly regarding transparency, traceability, and data reliability. Through a distributed ledger that is permanent and immutable, blockchain provides a secure record of every activity in the production and distribution flow of halal products (Alourani & Khan, 2024). Key characteristics such as immutability, transparency, and traceability allow all stakeholders to verify the origin of materials, production processes, and halal compliance in real-time, thereby minimizing the risks of fraud and labeling errors (Julian et al., 2025). Moreover, the use of smart contracts helps automate halal certification verification, ensuring that each process stage can only proceed if it meets the established Sharia requirements.

The integration of Artificial Intelligence (AI) into blockchain further strengthens the role of this technology in the halal supply chain. AI enables risk prediction, anomaly detection, and automatic identification of potential errors in certification or product labeling. For instance, platforms such as SiHalal in Indonesia have utilized AI to improve the accuracy and efficiency of halal certification processes, while also providing better visibility of halal product flows (Ridho, 2025). The use of AI also facilitates faster decision-making and supports SME operations, so that the combination of AI and blockchain helps overcome critical challenges such as fraud, labeling errors, and limited resources in halal oversight (Khan et al., 2025). Thus, blockchain continues to serve as a transparent and immutable recording system, while AI adds analytical, predictive, and real-time risk detection capabilities.

This technological integration not only reduces information fragmentation and improves documentation flow but also enhances the efficiency and accuracy of halal supervision throughout the supply chain (Sunmola et al., 2025). Furthermore, the implementation of blockchain allows halal-certified SMEs to strengthen the resilience of their supply chains, which ultimately contributes to overall company performance improvement (Nugraha et al., 2025). This technological foundation becomes a crucial basis for the Qualitypreneur approach in reinforcing halal value through innovation, quality, and consumer trust.

4.2 AI-Enhanced Qualitypreneur Approach for Strengthening Halal–Tayyib Quality Assurance

The Tetrapreneur framework is a comprehensive entrepreneurial concept built upon four main pillars: Chainpreneur, Marketpreneur, Qualitypreneur, and Brandpreneur. These four pillars are designed to strengthen business development through supply chain management, market understanding, quality assurance, and brand value enhancement, all of which are interconnected (Fatimah, 2018). In the context of the halal industry, the Tetrapreneur concept provides a strategic perspective that not only focuses on business processes but also emphasizes sharia compliance as a fundamental value embedded in every stage of production and distribution. Although all pillars complement each other, Qualitypreneur becomes the most relevant component for halal–tayyib quality assurance because it focuses directly on ensuring consistent quality and compliance throughout all stages of the supply chain.

Qualitypreneur emphasizes the implementation of comprehensive quality principles through Total Quality Management (TQM), which requires the involvement of all stakeholders within the production chain to ensure consistent fulfillment of halal standards (Oakland, 2014). In the modern context, the capacity of TQM to uphold halal quality is further strengthened through the use of artificial intelligence (AI) technologies. AI enables faster and more accurate assessments of compliance, such as automated analysis of ingredient documents, supplier histories, or formulation changes that may affect halal status. This complements traditional TQM mechanisms with predictive insights and early detection capabilities, ensuring that any updates or modifications in the production line remain aligned with halal standards.

The application of TQM within the Qualitypreneur approach also highlights the importance of strengthening the competencies of halal industry actors through continuous training (Devi & Fatimah, 2025). With the integration of AI, these training programs can be enhanced through adaptive learning platforms, AI-driven halal audit simulations, and recommendation systems that automatically tailor learning materials to the specific needs of participants. Such technologies help halal auditors, business actors, and technical personnel to better understand the evolving national and international halal standards, including changes in raw materials and production technologies. Through AI support, competency development becomes more efficient, measurable, and personalized.

Beyond human resource capacity building, Qualitypreneur also requires periodic audits of halal products to ensure no deviations occur in the use of materials, production processes, or distribution channels. Systematic audits carried out by Halal Inspection Bodies (LPH) and certified auditors function as early detection mechanisms against potential violations that could undermine halal integrity and consumer trust. With recent technological advancements, AI adds significant value to the audit process by identifying patterns of anomalies in production data, distribution records, or certification documents, enabling auditors to detect potential discrepancies earlier.

AI can also assist in verifying data consistency among suppliers, manufacturers, and distributors, making audits more objective and accurate while maintaining the essential role of human auditors as the primary decision-makers.

To enhance the effectiveness of audits, auditor competencies and LPH standards must be continuously evaluated to remain aligned with regulatory developments and technological advancements. Furthermore, the Qualitypreneur framework encourages governments to provide regulations that support product innovation through research collaborations with universities, enabling the industry to continuously enhance halal-tayyib quality in an innovative environment (Devi & Fatimah, 2025). AI contributes significantly to this agenda by offering data analytics tools, halal risk modeling, and decision-support systems for regulators, researchers, and industry actors. Thus, Qualitypreneur serves as a vital foundation for ensuring that quality, trustworthiness, and sharia compliance are upheld across all elements of Halal Supply Chain Management (HSCM), while also promoting a technology-oriented and adaptive quality assurance approach.

4.3 Integration of Halal Blockchain Technology with the Qualitypreneur Approach to Enhance Consumer Trust in Halal Products

The integration of halal blockchain technology with the Qualitypreneur approach serves as a strategic foundation for strengthening consumer trust, as both emphasize transparency, quality, and Shariah compliance. Within the context of Halal Supply Chain Management (HSCM), blockchain functions as a distributed ledger system that provides permanent, accurate, and verifiable data regarding the entire production and distribution processes of halal products. Features such as immutability, real-time traceability, and automated verification through smart contracts ensure that every activity within the supply chain is clearly documented and resistant to manipulation (Julian et al., 2025; Sunmola et al., 2025). These advantages address fundamental HSCM challenges such as weak traceability, fraud risks, and information fragmentation that have historically undermined halal integrity.

The integration of artificial intelligence (AI) further strengthens the capabilities of blockchain in establishing a more accurate and proactive halal monitoring system. AI can perform real-time analysis of supply chain data, detect anomalies that may indicate potential halal non-compliance, and identify risk patterns that are difficult to detect manually (Mahmudy & Kurnianingtyas, 2025). With predictive algorithms, AI can anticipate contamination points, fraud risks, or procedural violations, allowing preventive measures to be taken more rapidly and effectively. This analytical capability expands blockchain's function from merely recording data to operating as an intelligent monitoring system capable of automatically validating halal integrity. The enhanced transparency and accountability facilitated by AI and blockchain simultaneously contribute to the formation of positive attitudes and consumer perceptions of control over halal products, as explained in the Theory of Planned Behavior (Barbera & Ajzen, 2020). Consumers are more likely to trust and intend to consume halal products when they are able to verify information and observe immutable evidence of Shariah compliance.

Meanwhile, Qualitypreneur one of the pillars within the Tetrapreneur framework emphasizes the importance of quality assurance, continuous evaluation, and trustworthiness throughout all halal business processes (Fatimah, 2018). These principles align with Total Quality Management (TQM), which prioritizes continuous monitoring, regular audits, enhanced auditor competence, and standardized procedures for production and distribution to maintain halal-tayyib consistency (Oakland, 2014). Within the context of technological development, AI further strengthens Qualitypreneur principles by providing automated audit support, such as detecting errors in certification documents, monitoring the quality of raw materials, and systematically assessing process compliance. This reinforcement of control systems not only secures product integrity but also shapes subjective norms that encourage consumers to prefer products with strong halal assurance norms that reflect the belief that consuming high-quality halal products is socially and religiously appropriate (Fishbein & Ajzen, 1975). Thus, the Qualitypreneur principle helps build the perception that certified halal products are safer, more reliable, and fully aligned with Shariah values.

The intersection between Qualitypreneur and blockchain lies in their shared demands for transparency, accountability, and consistent quality. Qualitypreneur requires continuous evaluation systems, verifiable documentation, and objective auditing mechanisms that are resistant to manipulation (Fatimah, 2018; Oakland, 2014). Blockchain provides the digital infrastructure needed to fulfill these requirements through immutable records, real-time process visibility, and smart contracts that ensure automatic procedural compliance at every stage of the supply chain (Alourani & Khan, 2024; Julian et al., 2025). AI strengthens this collaboration by offering deep analytical capabilities, automated validation of audit data, and risk classification based on supplier or process history. This integration directly enhances perceived behavioral control, as consumers feel more capable of making informed decisions due to increased access to evidence and halal audit trails validated by intelligent technologies.

The combination of blockchain, AI, and Qualitypreneur ultimately forms transparency-based trust a type of trust built on open information, consistent quality, and verifiable Shariah compliance. Through transparent

production records and more accurate audits, consumers gain assurance that halal products truly meet the required Shariah and quality standards. Smart contracts ensure that all stages of production adhere strictly to halal requirements, while Qualitypreneur principles ensure that each process is supervised by competent auditors following rigorous quality standards. AI strengthens both elements through automated evaluations and early detection of deviations, resulting in more efficient, objective, and reliable oversight. From the perspective of the Theory of Planned Behavior, this environment simultaneously reinforces consumer attitudes, subjective norms, and perceived behavioral control, ultimately increasing intent to trust and intent to purchase halal products sustainably. This integration produces a conceptual model in which technology and Shariah-based values work harmoniously to reinforce halal integrity, enhance industry credibility, and ultimately strengthen consumer trust in halal products.

Conclusion

This study highlights that integrating AI-augmented halal blockchain with the Qualitypreneur framework offers a strategic and technically robust approach to strengthening consumer trust in the sustainable halal industry. Blockchain provides immutable, transparent, and traceable records across the halal supply chain, while AI enhances system intelligence through real-time analytics, anomaly detection, and predictive risk assessment. Together, these technologies address fundamental weaknesses in Halal Supply Chain Management, including traceability gaps, fraud risks, and information fragmentation.

The Qualitypreneur framework complements these advancements by reinforcing continuous quality assurance, structured audits, competency development, and adherence to halal-tayyib standards. The synergy between blockchain, AI, and Qualitypreneur principles creates a comprehensive assurance model that enhances transparency, accountability, and operational integrity throughout the supply chain. From the perspective of the Theory of Planned Behavior, this integration strengthens consumer attitude, subjective norms, and perceived behavioral control, thereby increasing trust and purchase intention toward halal products. Overall, the proposed model demonstrates how technological innovation and syariah-driven quality management can jointly reinforce the credibility, sustainability, and resilience of the halal industry in a rapidly evolving digital landscape.

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