

Reshaping the Halal Supply Chain through Strategic Modernization for Sustainable Development and Global Market Access

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Abstract: *The halal economy has become a rapidly expanding component of global trade, yet its supply chains remain constrained by structural and operational inefficiencies. Fragmented certification systems, limited technological adoption, weak organizational capacity, inconsistent sustainability integration, and barriers to international trade continue to undermine competitiveness and consumer trust. This article examines how strategic modernization can reshape halal supply chains to achieve sustainable development and greater access to global markets. Drawing on a review of recent literature and critical analysis of contemporary practices, the study highlights the transformative potential of integrating blockchain, Internet of Things, and artificial intelligence to enhance traceability and efficiency. It also emphasizes the importance of organizational readiness, skills development, and inclusive participation of small and medium enterprises to ensure equitable modernization. Sustainability emerges as a central pillar, with findings indicating that halal values are closely aligned with environmental stewardship, ethical labor practices, and responsible consumption, although operationalization remains inconsistent. The article argues that modernization must be holistic, combining technological, organizational, and institutional reforms to strengthen halal integrity and global legitimacy. By developing a framework that connects modernization strategies with sustainability outcomes and market access, this research contributes theoretical insights and practical guidance for policymakers, industry leaders, and certification bodies. The findings underscore that strategic modernization is both an operational necessity and a developmental imperative for the long-term competitiveness of the halal supply chain.*

Keywords: Halal, Modernization, Sustainability, Certification, Technology

1. Introduction

The halal economy has emerged as one of the most dynamic sectors in the global marketplace, extending far beyond food into pharmaceuticals, cosmetics, logistics, and tourism. Its growing influence is tied to both the demographic expansion of the Muslim population and the increasing appeal of halal products among non-Muslim consumers who associate halal with cleanliness, safety, ethical standards, and traceability (Zafar, 2025; Harsanto et al., 2024). Current projections suggest that the global halal market will continue to expand rapidly, surpassing trillions of dollars in value and becoming a cornerstone of sustainable international trade (Karia, 2025). Despite its potential, the halal supply chain remains constrained by

fragmentation, inconsistent certification, insufficient digitalization, and weak integration of sustainability principles (Kurniawati et al., 2023; Abbas et al., 2025). These limitations hinder competitiveness, undermine trust, and restrict access to global markets. To overcome these barriers, there is a pressing need to reshape halal supply chains through strategic modernization that simultaneously secures halal integrity, advances sustainable development, and enhances global market integration.

The halal supply chain is distinctive because it must uphold Shariah principles at every stage of value creation, from sourcing of raw materials to consumption. This requires stringent segregation of halal and non-halal flows, rigorous certification, and continuous traceability (Kurniawan et al., 2025; Harsanto et al., 2024). These requirements go beyond the priorities of conventional supply chains, which often emphasize cost efficiency and speed of delivery, adding layers of complexity to halal operations. However, these requirements also provide opportunities to differentiate halal supply chains as models of ethical and sustainable practices in global commerce (Asmadi et al., 2025). For halal producers, aligning operations with consumer expectations of safety, transparency, and sustainability is no longer optional but essential for competitiveness.

Scholars emphasize that incremental adjustments are insufficient to address the structural weaknesses of halal supply chains. Instead, comprehensive modernization is required, defined as the deliberate reconfiguration of processes, technologies, governance structures, and human capabilities with a view to long-term competitiveness (Moghaddam & Nof, 2022; McKinnon, 2018). Strategic modernization is not simply about digitization but about aligning modernization efforts with broader objectives, including sustainability and global trust. For instance, advanced technologies such as blockchain, Internet of Things (IoT), and artificial intelligence are being adopted to improve traceability, transparency, and efficiency in halal supply chains (Harsanto et al., 2024; Yakubu et al., 2025). Blockchain applications such as HalalChain have demonstrated potential to automate certification processes, minimize reliance on intermediaries, and ensure immutable records of halal flows, thereby reinforcing trust and reducing inefficiencies (Yakubu et al., 2025). Integrative approaches combining blockchain and artificial intelligence can further enhance anomaly detection and fraud prevention in halal supply chains, which are particularly vulnerable to risks of mislabeling and contamination (Alourani & Khan, 2024). Beyond technology, business process reengineering tailored to halal contexts has been proposed to reduce cycle times, enhance synchronization among actors, and embed proactive controls that minimize non-compliance (Belkhatir et al., 2020). These modernization initiatives collectively demonstrate the necessity of holistic strategies that involve technology, process redesign, governance reform, and human capital development.

Sustainability is central to reshaping halal supply chains, not only because it resonates with Islamic values of stewardship and fairness but also because global market competitiveness increasingly depends on sustainability credentials. Despite this, many studies note that the environmental and social dimensions of sustainability remain underexplored in halal contexts, with existing literature focusing predominantly on certification and logistics (Kurniawati et al., 2023). Recent research advocates for embedding green logistics, renewable energy usage in cold chain systems, sustainable packaging, and waste minimization into halal supply chains (Azhar & Tu, 2021; Showole et al., 2025). A multi-theory approach has been suggested to integrate institutional, relational, and resource-based perspectives to explain sustainability performance in halal supply chains, yet empirical testing remains limited (JIMA, 2025). The incorporation of ESG frameworks provides another pathway, with evidence suggesting that ESG principles are compatible with halal values and can enhance legitimacy and global

credibility (Asmadi et al., 2025). For example, sustainable procurement has been shown to play a critical role in shaping halal supply chain practices, driving improvements in certification transparency, waste management, and operational efficiency (Ghalih et al., 2025). This highlights the potential of modernization to position halal supply chains as leaders in ethical and sustainable global trade.

While modernization strengthens sustainability, it also facilitates global market access, which has become a strategic ambition for halal producers. Increasingly, halal certification is recognized not only as a religious necessity but also as a signal of product quality, safety, and ethical assurance for international consumers (Zafar, 2025; Abbas et al., 2025). This is particularly relevant in non-Muslim majority markets where halal products are perceived as premium or safe options. Nonetheless, cross-border halal trade faces persistent challenges, including regulatory heterogeneity, certification fragmentation, and lack of mutual recognition agreements. These barriers increase transaction costs, erode consumer trust, and complicate international supply chain integration (Putra Timur et al., 2025; Suhadi et al., 2024). For example, Indonesia's recent establishment of the Halal Product Assurance Organizing Agency represents an effort to centralize certification and improve global competitiveness, while Pakistan's Halal Authority has struggled with institutional maturity and credibility (Khan & Hussain, 2025). Such disparities underscore the need for interoperable and digitally enabled certification systems to support trust and transparency across borders. Research indicates that consumer acceptance of halal products is increasingly linked to reliable traceability systems supported by technologies like blockchain and IoT, which offer both compliance and competitiveness advantages (Kurniawan et al., 2025; Yakubu et al., 2025). Strategic modernization therefore provides a pathway not only to strengthen internal efficiency but also to reduce barriers in global markets and enhance international legitimacy.

Despite the clear advantages of modernization, multiple challenges impede progress. Technological adoption remains uneven, with many halal firms, particularly small and medium enterprises, facing constraints related to infrastructure, cost, and digital literacy (Changalima, 2025). Interoperability and cybersecurity concerns further complicate the integration of advanced technologies (Harsanto et al., 2024). Financial constraints are especially acute, since modernization often requires significant up-front investment with uncertain short-term returns (Abbas et al., 2025). Human capital shortages also present obstacles, as specialized skills in halal assurance, sustainability, and data analytics are still underdeveloped in many regions (Halal Supply Chain Competencies, 2023). Institutional fragmentation may be the most significant barrier, as multiple certification bodies apply different standards, resulting in inconsistent recognition and reduced trust (Putra Timur et al., 2025). Without harmonization, modernization risks intensifying existing inefficiencies and inequities, particularly if smaller firms are excluded from global supply chains because of cost and capacity barriers (Showole et al., 2025).

The literature to date provides valuable insights into halal logistics, certification, and traceability, yet major research gaps remain. First, few studies offer an integrated framework that simultaneously addresses modernization, sustainability, and global market access. Second, much of the research is conceptual or descriptive, with limited empirical testing of modernization frameworks in halal contexts (Kurniawati et al., 2023). Third, there is insufficient comparative analysis across firm sizes and regions, leaving uncertainty about the generalizability of modernization strategies (Abbas et al., 2025). Fourth, while technologies such as blockchain and IoT are often highlighted, little is known about how their adoption concretely reduces non-tariff barriers and enhances trust in cross-border trade. Addressing

these gaps requires robust empirical research that connects modernization strategies with measurable outcomes in sustainability and international competitiveness.

This paper seeks to contribute to the literature by developing and testing a strategic modernization framework for halal supply chains. The framework integrates modernization levers such as technology adoption, process reengineering, governance reform, and human capability development with sustainability outcomes and global market access performance. By empirically examining how modernization investments influence supply chain integrity, sustainability performance, certification credibility, and export competitiveness, the research provides both theoretical advancement and practical guidance. The contributions are fourfold. First, the paper offers a holistic conceptualization of modernization in halal supply chains that aligns with sustainability and market goals. Second, it empirically investigates the framework across different contexts to identify maturity levels, constraints, and outcomes. Third, it develops policy and managerial recommendations to support inclusive and equitable modernization pathways. Fourth, it enhances generalizability by comparing effects across regions and firm sizes, thereby providing guidance for both large multinationals and small enterprises seeking entry into global halal markets.

The overarching argument of this study is that halal supply chains must move from fragmented and compliance-driven systems to strategically modernized, sustainable, and globally integrated networks. Modernization must not be pursued in isolation but in concert with sustainability imperatives and global recognition requirements. It must prioritize inclusivity, ensuring that small and medium enterprises are not left behind. By reshaping the halal supply chain through strategic modernization, industry stakeholders can not only safeguard halal integrity but also drive sustainable development and achieve greater access to international markets.

2. Literature Review

The discussion in the introduction emphasized the need for halal supply chains to undergo modernization in order to align with sustainability and global market access. The literature reflects this call, with scholars examining halal supply chain management from multiple angles. To ensure clarity and comprehensiveness, this review is organized into five thematic areas: the foundations of halal supply chain management, digital technologies for modernization, organizational and process transformation, sustainability integration, and global market access dynamics. Together, these themes provide a holistic picture of the state of scholarship and highlight the research gaps that this study addresses.

2.1 Foundations of Halal Supply Chain Management

The first body of literature explores the foundational principles and distinctive features of halal supply chain management. Scholars agree that halal supply chains must preserve Shariah compliance across all stages of value creation, ensuring separation of halal and non-halal flows, rigorous certification, and integrity in logistics (Kurniawati et al., 2023; Harsanto et al., 2024). This requirement differentiates halal supply chains from conventional ones, which often prioritize cost efficiency and delivery speed without such strict integrity considerations (Abbas et al., 2025). Recent reviews have highlighted that much research has been descriptive, focusing on certification systems and logistics arrangements without adequately linking them to modernization strategies (Changalima, 2025). Consumer-focused studies also point out that the halal label is increasingly associated not only with religious compliance but also with ethical, safe, and transparent production (Zafar, 2025). This evolving perception raises the bar

for halal supply chain governance and indicates the necessity of more holistic frameworks that extend beyond certification to modernization and sustainability.

2.2 Digital Technologies for Modernization

The second stream of research emphasizes the role of digital technologies in reshaping halal supply chains. Blockchain has emerged as one of the most widely discussed tools due to its ability to create immutable, transparent records of halal flows, thereby automating certification and reducing fraud (Yakubu et al., 2025). IoT devices provide real-time monitoring of logistics conditions such as temperature and humidity, ensuring halal integrity during storage and transportation (Kurniawan et al., 2025). Artificial intelligence adds predictive capabilities for anomaly detection and demand forecasting, while big data analytics can optimize production and distribution networks (Alourani & Khan, 2024). A systematic review of Industry 4.0 adoption in halal contexts confirmed the growing role of digital tools in improving efficiency and transparency, but also found that implementation is uneven and often restricted to larger firms (Harsanto et al., 2024). A bibliometric analysis of halal certification research further showed that although technology is increasingly discussed, actual integration into certification practice remains limited (Putra Timur et al., 2025). These findings illustrate both the promise of digital modernization and the barriers of cost, interoperability, and digital literacy that restrict widespread adoption.

2.3 Organizational and Process Transformation

A third body of scholarship explores organizational change and process reengineering as pathways to modernization. Belkhatir et al. (2020) argue that halal supply chains must be redesigned through business process reengineering to reduce cycle times, minimize risks of contamination, and enhance coordination across actors. Other scholars highlight the importance of supply chain integration, showing that tighter coordination among suppliers, internal operations, and customers enhances both halal compliance and operational efficiency (Showole et al., 2025). However, organizational readiness and human capital remain persistent challenges. Research on halal supply chain competencies reveals that many firms, especially small and medium enterprises, lack training in halal assurance, digital systems, and sustainability practices (Halal Supply Chain Competencies, 2023). This shortage of skills underscores the argument that modernization requires not only new technologies but also investment in people, governance, and institutional culture. Without these elements, modernization risks remaining superficial or fragmented.

2.4 Sustainability Integration in Halal Supply Chains

The fourth theme addresses sustainability, which has become increasingly important in both academic and policy discourse. Halal values align naturally with sustainability through principles of stewardship, fairness, and ethical consumption, yet the literature indicates that sustainability remains underdeveloped in halal supply chain research (Kurniawati et al., 2023). Empirical studies suggest that halal supply chains can contribute to sustainable development goals by adopting green logistics, renewable energy solutions, sustainable packaging, and ethical labor practices (Azhar & Tu, 2021). A recent framework integrating ESG with halal logistics highlights the compatibility of Islamic values with global sustainability norms, suggesting that ESG adoption can enhance legitimacy and international trust (Asmdi et al., 2025). Quantitative studies also demonstrate the importance of sustainable procurement, showing that it influences transparency, waste management, and certification credibility (Ghalih et al., 2025). Nevertheless, systematic reviews confirm that sustainability in halal supply chains is often discussed at a conceptual level without rigorous empirical validation

(JIMA, 2025). This indicates a need for more evidence-based research that measures the real impact of sustainability adoption in halal contexts.

2.5 Global Market Access and Institutional Challenges

The final stream of literature examines global market access, highlighting the institutional and consumer dimensions of halal supply chain modernization. Studies show that halal certification is increasingly viewed by international consumers as a proxy for safety, quality, and ethical assurance (Abbas et al., 2025). Yet fragmented certification regimes, non-tariff barriers, and lack of mutual recognition hinder cross-border halal trade (Putra Timur et al., 2025). Comparative case studies reveal that while Indonesia has centralized halal certification through the Halal Product Assurance Organizing Agency to improve competitiveness (Suhadi et al., 2024), Pakistan continues to struggle with regulatory maturity and credibility (Khan & Hussain, 2025). These disparities underscore the importance of harmonizing certification standards and adopting interoperable digital systems that enhance transparency. Consumer studies further indicate rising demand for traceable halal products, which can be met through blockchain and IoT-enabled systems that provide credibility and global legitimacy (Kurniawan et al., 2025; Yakubu et al., 2025). However, scholars caution that modernization initiatives risk excluding smaller enterprises if equity and inclusiveness are not prioritized (Showole et al., 2025). This highlights the need for modernization pathways that are scalable and adaptable across diverse institutional and market contexts.

3. Constraints to Strategic Modernization of Halal Supply Chains

While the literature review has highlighted the growing body of research on halal supply chain modernization, sustainability, and global competitiveness, it also reveals persistent shortcomings that continue to hinder progress. These shortcomings can be understood as structural and operational issues that affect certification systems, digital modernization, organizational readiness, sustainability adoption, and market integration. The complexity of halal supply chains, combined with fragmented institutions and uneven capacities, has created systemic barriers that prevent the industry from achieving its full potential. By critically examining these issues, it becomes possible to identify where modernization efforts must be focused to ensure that halal supply chains evolve into sustainable and globally competitive networks.

3.1 Certification and Regulatory Fragmentation as a Barrier to Halal Supply Chain Modernization

Halal certification is the central mechanism through which trust and credibility are established in halal supply chains. It assures consumers that products meet the requirements of Shariah, but the literature shows that fragmentation of certification regimes across countries continues to undermine efficiency, reliability, and global competitiveness (Putra Timur et al., 2025). The absence of harmonized standards forces firms to secure multiple certifications when exporting, which raises costs and delays market entry (Abbas et al., 2025). This has created a complex environment where companies operating in global supply chains face redundancies and inconsistencies in compliance. Indonesia's establishment of the Halal Product Assurance Organizing Agency in 2024 represents an attempt to consolidate certification processes and provide international credibility (Suhadi et al., 2024). By contrast, Pakistan's halal certification authority has struggled with institutional weaknesses and a lack of recognition in global markets, reducing its capacity to facilitate exports (Khan & Hussain, 2025).

Scholars argue that certification fragmentation also affects consumer confidence. Research indicates that in non-Muslim majority markets, many buyers perceive halal certification as inconsistent, with varying degrees of enforcement and oversight (Zafar, 2025). This skepticism is amplified by cases of fraud, mislabeling, and certification disputes, which damage the broader reputation of halal supply chains (Harsanto et al., 2024). Institutional theory suggests that regulatory coherence is critical to modernization, as fragmented rules create uncertainty and weaken institutional legitimacy (McKinnon, 2018). Efforts to establish mutual recognition agreements between countries have been limited, leaving producers in a position where they must adapt to different standards for each export market (Karia, 2025).

From a modernization perspective, certification fragmentation undermines the scalability of halal supply chains. Without standardized recognition, firms are unable to capitalize fully on digital traceability systems that could streamline certification processes across borders (Yakubu et al., 2025). Moreover, small and medium enterprises (SMEs), which already face financial and organizational constraints, are disproportionately burdened by duplicative certification requirements (Changalima, 2025). As long as fragmentation persists, certification will remain a bottleneck for modernization, restricting efficiency and obstructing global integration.

3.2 Technological and Digital Modernization Challenges in Ensuring Transparency and Efficiency

Digital transformation has been identified as a cornerstone of halal supply chain modernization. Tools such as blockchain, Internet of Things (IoT), artificial intelligence (AI), and big data analytics promise to improve traceability, enhance efficiency, and reinforce consumer trust (Moghaddam & Nof, 2022). Blockchain solutions such as HalalChain offer immutable records that can automate certification and reduce opportunities for fraud (Yakubu et al., 2025). IoT sensors are capable of monitoring logistics conditions in real time, ensuring halal integrity during storage and transport (Kurniawan et al., 2025). AI can predict demand, optimize routes, and detect anomalies that might compromise compliance (Alourani & Khan, 2024).

Despite these promises, adoption of digital technologies is uneven. Large multinational firms with sufficient resources are able to implement advanced systems, but SMEs often face barriers including high costs, lack of expertise, and insufficient infrastructure (Changalima, 2025). A systematic review of Industry 4.0 applications in halal contexts confirmed that while adoption is increasing, it remains limited to resource-rich firms and markets (Harsanto et al., 2024). Cybersecurity concerns also pose significant challenges. Firms remain cautious about data sharing, fearing breaches that could compromise sensitive information about certification and logistics (Putra Timur et al., 2025).

The lack of interoperability among systems exacerbates these challenges. Different blockchain platforms and digital certification systems often fail to integrate, creating silos rather than seamless transparency (Asmadi et al., 2025). Furthermore, policy support for digital adoption is inconsistent. In many developing halal economies, governments have yet to create incentives or standards for technological integration, leaving adoption to the discretion of individual firms (Ghalih et al., 2025). This digital divide not only limits transparency and efficiency but also creates inequities within the halal economy, as SMEs risk being excluded from modernized supply chains (Abbas et al., 2025).

3.3 Organizational Readiness and Human Capital Weakness Limiting Strategic Transformation

Modernization of halal supply chains is not only a technical process but also an organizational one. Firms require skilled personnel, effective governance, and cultural readiness to adopt new practices. However, research consistently shows that many halal firms lack employees trained in halal assurance, sustainability, and digital systems (Halal Supply Chain Competencies, 2023). This gap in human capital is one of the major bottlenecks in modernization. Business process reengineering, often cited as a strategy for improving synchronization and reducing inefficiencies, cannot succeed without adequate skills and leadership support (Belkhatir et al., 2020).

Organizational resistance to change is another obstacle. Studies show that firms often experience inertia when implementing new systems, with managers reluctant to adopt unfamiliar practices or invest in training (Showole et al., 2025). This cultural resistance slows down modernization even when technological solutions are available. From a resource-based view, human capital is central to competitive advantage, and firms that invest in training are more likely to achieve sustainable modernization (Moghaddam & Nof, 2022). Yet investment in skills development remains insufficient, particularly among SMEs with limited resources (Changalima, 2025).

The literature also highlights a lack of organizational integration. Effective modernization requires collaboration among suppliers, logistics providers, certifiers, and regulators, but halal supply chains are often fragmented and characterized by weak coordination (Harsanto et al., 2024). Relational perspectives emphasize that trust and collaboration are critical, but these are often undermined by competition and lack of information sharing (Zafar, 2025). Without organizational readiness and strong human capital, modernization risks being superficial and unable to deliver long-term improvements.

3.4 Sustainability Integration Remaining More Conceptual Than Operational in Halal Supply Chains

Sustainability has become a dominant theme in supply chain research, and halal principles are naturally aligned with sustainable practices such as fairness, ethical sourcing, and stewardship. However, the literature suggests that sustainability integration in halal supply chains remains more conceptual than operational (Kurniawati et al., 2023). While ESG frameworks have been proposed to align halal values with sustainability principles (Asmdil et al., 2025), adoption in practice remains limited.

Empirical studies indicate that larger multinational firms are more likely to adopt practices such as renewable energy in cold chains, sustainable packaging, and waste reduction (Azhar & Tu, 2021). SMEs, however, often lack the resources or expertise to integrate sustainability measures, creating an uneven playing field (Abbas et al., 2025). A DEMATEL-based study demonstrated that sustainable procurement significantly influences certification transparency and waste management (Ghalih et al., 2025), yet many firms continue to prioritize certification compliance over sustainability performance.

Reviews also highlight that sustainability research in halal supply chains is frequently conceptual, lacking empirical testing or performance measurement (JIMA, 2025). This creates a gap between theoretical potential and actual implementation. As global consumers increasingly demand sustainable products, halal supply chains risk falling behind if sustainability continues to be treated as secondary to certification. For modernization to be

credible and globally competitive, sustainability must move from conceptual frameworks to operational practices across all levels of the supply chain.

3.5 Global Market Access Undermined by Trade Barriers and Consumer Skepticism

Expanding halal products into global markets remains an aspiration for many producers, but significant barriers persist. Halal certification is increasingly recognized by international consumers as a signal of quality and safety (Abbas et al., 2025), yet skepticism remains due to fragmented certification systems and limited traceability (Zafar, 2025). In non-Muslim majority markets, buyers demand transparency and evidence of compliance, but many halal supply chains lack interoperable systems capable of providing such assurance (Kurniawan et al., 2025).

Blockchain and IoT offer potential solutions to enhance trust, but adoption is still limited, leaving many exporters unable to meet international buyer requirements (Yakubu et al., 2025). Institutional disparities across countries further weaken global competitiveness. Indonesia's centralized certification system has improved export capacity (Suhadi et al., 2024), while Pakistan's struggles continue to restrict market access (Khan & Hussain, 2025). SMEs face disproportionate challenges due to high costs of certification, limited access to financing, and lack of international networks (Changalima, 2025).

Without addressing these barriers, halal supply chains will continue to struggle to penetrate competitive non-Muslim markets. Consumer perception studies confirm that transparency and traceability are key drivers of trust, suggesting that modernization must prioritize these elements to gain international legitimacy (Asmadi et al., 2025). Global market access remains undermined by regulatory fragmentation, limited technology adoption, and uneven institutional capacity, all of which restrict the ability of halal supply chains to achieve sustainable growth.

4. Analytical Perspectives on Modernizing the Halal Supply Chain

The preceding analysis of issues revealed that halal supply chains are constrained by fragmentation, uneven modernization, weak organizational readiness, limited sustainability integration, and restricted global market access. The discussion section synthesizes these issues by highlighting how strategic modernization can offer pathways to resolve them. To ensure clarity, the discussion is presented in five thematic areas: institutional reforms in certification, inclusive technology adoption, organizational transformation and human capital development, operationalization of sustainability, and strategies for expanding global market access.

4.1 Institutional Reforms in Certification and Governance

The fragmentation of halal certification remains one of the most pressing barriers to modernization. Without harmonized standards, firms must undergo duplicative certification processes that increase costs and reduce competitiveness in export markets (Abbas et al., 2025). Institutional theory highlights that coherent regulation is essential for legitimacy, and fragmented systems create uncertainty (McKinnon, 2025). Indonesia's centralization of certification under the Halal Product Assurance Organizing Agency has strengthened credibility and market access (Suhadi et al., 2024). Conversely, Pakistan continues to struggle with weak institutional frameworks that undermine international recognition (Khan & Hussain, 2025). Digitalization of certification through blockchain can reduce duplication and provide a common platform for recognition across borders (Yakubu et al., 2025). Mutual recognition agreements between countries could also play a significant role in eliminating trade frictions

(Karia, 2025). Thus, institutional reforms combining policy harmonization and digital systems are central to modernization.

4.2 Inclusive Technology Adoption for Transparency and Efficiency

Digital technologies are widely seen as enablers of modernization, yet their adoption remains uneven. Blockchain platforms provide immutable records of halal flows, IoT sensors enable real-time logistics monitoring, and AI supports anomaly detection and forecasting (Alourani & Khan, 2024; Harsanto et al., 2024). While large firms have adopted these systems, small and medium enterprises face barriers related to cost, expertise, and infrastructure (Changalima, 2025). This digital divide undermines inclusivity and reduces the overall transparency of halal supply chains. From a resource-based perspective, firms that adopt digital systems achieve superior performance, but wider adoption requires institutional support (Moghaddam & Nof, 2022). Governments and industry bodies can provide incentives, training, and shared digital infrastructure to enable SMEs to participate (Abbas et al., 2025). Moreover, interoperability and cybersecurity need to be addressed to ensure digital systems are trustworthy (Putra Timur et al., 2025). A collaborative and inclusive approach to technology adoption will ensure modernization benefits are shared across the halal economy.

4.3 Organizational Transformation and Human Capital Development

Organizational readiness and human capital development are critical but often neglected elements of modernization. Studies show that many halal firms lack staff trained in halal assurance, sustainability, and digital operations (Halal Supply Chain Competencies, 2023). Business process reengineering models emphasize synchronization and proactive monitoring (Belkhatir et al., 2020), but their effectiveness depends on leadership and workforce readiness. Cultural resistance to change remains a major barrier, slowing the adoption of new systems (Showole et al., 2025). The resource-based view underlines that human capital is a strategic resource for competitiveness (Moghaddam & Nof, 2022). Investment in training and capacity building is therefore essential for modernization. Policymakers and universities can collaborate to provide specialized programs on halal supply chain management, while firms must commit to continuous learning. Stronger collaboration across supply chain actors can also build trust and reduce fragmentation (Zafar, 2025). Organizational transformation, supported by human capital development, is essential for embedding modernization practices effectively.

4.4 Operationalizing Sustainability in Halal Supply Chains

Although halal principles align with sustainability, integration remains more conceptual than operational. ESG frameworks highlight compatibility between halal values and global sustainability standards (Asmdi et al., 2025), yet adoption of green logistics, renewable energy, and ethical labor practices is inconsistent (Azhar & Tu, 2021). Larger firms have implemented sustainability measures, but SMEs lag behind due to financial and technical barriers (Abbas et al., 2025). Quantitative studies confirm that sustainable procurement drives improvements in transparency and waste management (Ghalih et al., 2025), but empirical evidence of broader adoption is limited (Kurniawati et al., 2023). Global consumers increasingly expect sustainability credentials, associating them with credibility and trust (Zafar, 2025). To operationalize sustainability, halal supply chains must move beyond compliance and adopt proactive practices. Governments can introduce incentives for sustainable practices, and firms can collaborate to share resources and knowledge. Integrating sustainability into modernization strategies will strengthen both halal credibility and global competitiveness.

4.5 Strategies for Expanding Global Market Access

Global market access remains limited by trade barriers, fragmented certification, and consumer skepticism. Although halal certification is increasingly viewed as a marker of safety and quality, inconsistent systems undermine trust (Kurniawan et al., 2025). International buyers demand transparent and interoperable traceability systems, yet adoption of blockchain and IoT remains uneven (Yakubu et al., 2025). Institutional disparities also create uneven competitiveness, with some countries having advanced certification authorities while others remain weak (Suhadi et al., 2024; Khan & Hussain, 2025). SMEs face high costs in certification and export compliance, restricting their ability to compete globally (Changalima, 2025). Relational perspectives emphasize the importance of trust and collaboration across supply chain actors to overcome these barriers (Showole et al., 2025). Branding strategies that position halal products as safe, ethical, and sustainable could also improve acceptance in non-Muslim majority markets (Abbas et al., 2025). Expanding global market access therefore requires harmonized certification, digital traceability, institutional reforms, and consumer-focused branding strategies.

5. Strategic Directions for Sustainable Halal Supply Chain Development

The challenges identified in the earlier sections demonstrate that halal supply chains are currently constrained by institutional fragmentation, uneven technological adoption, organizational weaknesses, limited sustainability integration, and barriers to global market access. Addressing these issues requires actionable strategies that move beyond theoretical discussions to practical implementation. Suggestions in this section aim to provide a roadmap for policymakers, industry leaders, and academics to modernize halal supply chains in a way that enhances efficiency, safeguards integrity, and expands competitiveness. These proposals are informed by institutional theory, the resource-based view, relational perspectives, and sustainability frameworks, ensuring that they respond both to immediate operational concerns and to long-term strategic goals. By addressing institutional, technological, organizational, sustainability, and global dimensions, the suggestions provide an integrative framework for reshaping halal supply chains into systems that can thrive in an interconnected and competitive world economy.

5.1 Strengthening Institutional Frameworks and Harmonizing Certification

Halal certification is the foundation of trust in halal supply chains, yet fragmentation of standards across different countries continues to undermine global competitiveness. Multiple certifications are often required for exporters to access different markets, creating inefficiencies and raising costs (Abbas et al., 2025). Institutional theory emphasizes that coherent and harmonized regulation enhances legitimacy, while fragmented systems weaken trust (McKinnon, 2025). Indonesia's establishment of the Halal Product Assurance Organizing Agency provides an example of improved credibility through centralization (Suhadi et al., 2024). By contrast, countries with weaker institutional frameworks face challenges in gaining global recognition (Khan & Hussain, 2025).

Governments and international bodies can strengthen institutional frameworks by developing mutual recognition agreements that reduce duplication and facilitate trade (Putra Timur et al., 2025). Digital certification platforms supported by blockchain can create interoperable systems that automate verification and enhance transparency (Yakubu et al., 2025). Regional initiatives, such as ASEAN halal frameworks, can serve as models for broader harmonization (Harsanto et al., 2024). Strengthening governance and harmonizing certification standards will reduce inefficiencies and reinforce trust in halal supply chains globally.

5.2 Promoting Inclusive Technology Adoption for Transparency and Equity

Digital transformation is widely recognized as an enabler of halal supply chain modernization. Technologies such as blockchain, IoT, and artificial intelligence enhance traceability, logistics monitoring, and predictive analytics (Moghaddam & Nof, 2022; Alourani & Khan, 2024). However, implementation is uneven, with larger firms adopting these systems while small and medium enterprises face barriers related to cost, expertise, and infrastructure (Changalima, 2025). This imbalance undermines inclusivity in the halal economy.

Institutional support is critical for ensuring equitable access to digital solutions. Subsidies, tax incentives, and shared platforms can reduce the cost burden on smaller firms (Abbas et al., 2025). Training programs coordinated by governments and industry associations can improve digital literacy, while standardized interoperability protocols can prevent fragmented digital platforms from creating silos (Putra Timur et al., 2025). Cybersecurity frameworks must also be strengthened to ensure trust in digital systems (Asmdi et al., 2025). Inclusive technology adoption ensures that modernization benefits are accessible to all actors, enhancing transparency, efficiency, and equity.

5.3 Enhancing Organizational Readiness and Building Human Capital

Organizational transformation and human capital development are crucial for effective modernization. Many halal firms lack personnel trained in halal assurance, sustainability practices, and digital operations (Halal Supply Chain Competencies, 2023). Business process reengineering can improve synchronization and monitoring across operations but requires leadership commitment and workforce preparedness (Belkhatir et al., 2020).

Continuous investment in training is essential. Collaboration between universities, governments, and industry can generate specialized programs in halal logistics, certification management, and digital supply chain technologies (Kurniawati et al., 2023). Building a culture of adaptability is equally important, as resistance to change often delays modernization initiatives (Showole et al., 2025). Human capital is an intangible resource that drives competitiveness, and firms that develop skilled and adaptable workforces gain sustainable advantages (Moghaddam & Nof, 2022). By prioritizing organizational readiness and investing in people, halal supply chains can become more resilient and adaptive to global shifts.

5.4 Operationalizing Sustainability Beyond Compliance

Sustainability remains underdeveloped in halal supply chains despite the strong alignment between halal values and sustainable practices. Many firms limit their efforts to certification compliance without adopting comprehensive sustainability strategies (Kurniawati et al., 2023). ESG frameworks illustrate compatibility between halal and sustainability principles (Asmdi et al., 2025), but adoption is inconsistent across industries. Larger firms have incorporated renewable energy, ethical labor standards, and green logistics, while SMEs struggle due to resource limitations (Azhar & Tu, 2021; Abbas et al., 2025).

Operationalizing sustainability requires embedding it into procurement, production, and logistics practices. Research shows that sustainable procurement improves transparency and reduces waste (Ghalih et al., 2025). Policy incentives, such as tax reliefs for eco-friendly practices and stricter environmental regulations, can further encourage adoption (Harsanto et al., 2024). Consumers increasingly link halal products with ethical and sustainable values, meaning that firms adopting proactive sustainability strategies can strengthen both trust and competitiveness (Zafar, 2025). Integrating sustainability beyond compliance will allow halal supply chains to contribute meaningfully to global sustainable development goals.

5.5 Expanding Global Market Access Through Branding and Collaboration

Barriers to global market access remain significant for halal supply chains. Although certification is recognized internationally, fragmented standards and limited transparency continue to fuel skepticism among consumers and buyers (Kurniawan et al., 2025). Blockchain and IoT technologies can improve traceability, yet adoption is not widespread, leaving gaps in credibility (Yakubu et al., 2025). Institutional disparities also affect competitiveness, as some countries have advanced halal authorities while others remain underdeveloped (Suhadi et al., 2024; Khan & Hussain, 2025).

Expanding market access requires a combination of branding, collaboration, and regulatory reform. Branding strategies should reposition halal products as not only religiously compliant but also safe, ethical, and sustainable (Abbas et al., 2025). Collaboration among producers, certifiers, regulators, and international bodies can enhance consistency and strengthen trust (Showole et al., 2025). Regional and international partnerships can help reduce trade barriers and increase mutual recognition of standards (Putra Timur et al., 2025). Strengthening branding and collaboration will allow halal supply chains to expand more effectively into global markets while reinforcing consumer trust.

6. Conclusion

The halal supply chain is entering a decisive phase where modernization is no longer optional but essential for sustainability and global competitiveness. Although the halal economy continues to expand, its supply chains remain weakened by fragmented certification systems, uneven technology adoption, organizational capacity gaps, limited sustainability implementation, and barriers to international trade. These persistent challenges restrict efficiency, reduce consumer trust, and constrain integration into global markets.

Strategic modernization provides a comprehensive pathway to address these challenges. Redesigning processes, embedding digital technologies, strengthening governance, and developing human capital can transform halal supply chains from fragmented compliance-driven systems into sustainable and internationally integrated networks. Blockchain, Internet of Things, and artificial intelligence enhance traceability and transparency, while organizational readiness and skill development ensure that modernization becomes embedded within operational practices.

Sustainability should be positioned at the core of modernization. Although halal principles resonate with ethical consumption and stewardship, actual adoption of sustainable practices remains inconsistent. The integration of renewable energy, green logistics, waste reduction, and ethical labor practices can reinforce credibility, align halal operations with global development goals, and improve competitiveness in environmentally conscious markets. Equally important is the harmonization of certification standards and the creation of interoperable traceability systems that reduce trade frictions and improve access to international markets.

The overall contribution of this study lies in articulating a holistic perspective that links modernization, sustainability, and market access. Modernization must also be inclusive, ensuring that small and medium enterprises are not excluded due to financial or technical barriers. Further research should focus on empirical testing of modernization frameworks across regions and firm sizes, with particular attention to how digital innovation and sustainability practices strengthen competitiveness.

Halal supply chains can only achieve resilience and long-term legitimacy by pursuing modernization that is integrated, sustainable, and inclusive. Through such transformation, halal supply chains will be better positioned to safeguard Shariah integrity, build consumer confidence, contribute to sustainable development, and secure their role in global markets.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this study.

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