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Digital Ecosystems in Supporting Global Trade of Halal Products: Innovation and Challenges

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ABSTRACT

This research investigates the role of the digital ecosystem in enhancing trade in halal products within an increasingly competitive global market. this integration. This research employs a qualitative method, utilizing library research and content analysis techniques to examine various secondary sources, including scientific journals, industry reports, and documents from international institutions. The analysis process involved categorizing information based on key themes, including supply chain efficiency, transparency in certification, and regulatory challenges. The results show that digital technology can enhance market access, improve distribution efficiency, and increase consumer confidence in halal products. However, there are major challenges, including differences in international halal standards, limited digital infrastructure, and a lack of Sharia-based digital regulations and literacy. This study concludes that synergy among the government, business actors, and halal certification bodies is necessary to establish a robust and Sharia-compliant digital ecosystem. The findings make an important contribution to the development of an inclusive and sustainable global halal digitization strategy. The novelty of this research lies in its comprehensive approach to integrating digital innovations, such as blockchain, IoT, Digital Twin, Big Data, and AI, which have not been thoroughly researched in the academic literature, especially globally.

INTRODUCTION

Amid rapid globalization, the halal industry is undergoing a significant transformation, both in terms of global competition and changing consumer patterns. Since the development of the halal industry in the countries of the Organization of Islamic Cooperation (OIC) in the 1970s, the halal trend has become a global phenomenon that is not only dominated by Muslim countries but also by non-Muslim countries. Based on the report state the Global Islamic Economy Repor*t*, the global halal market is estimated to reach US$ 1.3 trillion by 2025 or around Rp 20,670 trillion (US$1= 15,900), jumping from US$ 899.9 million in 2018 with an average annual growth rate of 5.2% during the period 2018-2028 (BPJPH Chairman, 2024). The global halal market is projected to reach a value of USD 3.2 trillion by 2028. Halal products encompass various sectors, including food and beverages (USD 1.27 trillion), fashion (USD 295 billion), halal cosmetics and pharmaceuticals (USD 95 billion), tourism, and Islamic finance (Genta, 2025).

It is an interesting fact that several non-Muslim countries dominate the world's halal industry with five main players, namely America, India, Russia, Argentina, and Brazil. At the Southeast Asian level,

the halal industry is still dominated by Thailand. Indonesia's current position remains the world's fourth-largest consumer, behind Saudi Arabia, Malaysia, and the United Arab Emirates. Brazil, with a Muslim population of less than 1%, is the largest exporter of poultry meat to the Middle East. Australia plays a major role as a supplier of halal beef to OIC countries. China dominates the export of halal clothing to the Middle East, while South Korea is increasingly aggressively developing halal tourism. Japan views the halal industry as an economic driver, Thailand aspires to be the "halal kitchen of the world," and London has ambitions to become the Islamic financial hub in the West (Amalia, 2024).

The digital ecosystem plays an important role in building an integrated halal value chain. Halal product trading requires not only the availability of products that meet halal standards but also an efficient, transparent, and reliable distribution and promotion system. Technologies such as blockchain, the Internet of Things (IoT), artificial intelligence (AI), and e-commerce platforms are the primary instruments in ensuring the authenticity and traceability of halal products from upstream to downstream. The digital ecosystem also facilitates the establishment of connectivity between small and medium-sized enterprises (SMEs), halal regulators, certification bodies, and global consumers, thereby reducing geographical and administrative barriers in the trade process.

Earlier studies have highlighted the role of the Indonesian Muslim diaspora in driving the digital transformation of the halal market in South Korea, demonstrating how digital technology enhances halal literacy and expands the market through e-commerce (Musafak & Nikmah, 2024). Dharmayanti and Aziz (2024) discuss halal supply chain management as a solution to meet the needs of the global halal industry in the digital economy era. Muhamad Nazari et al. (2023) examine halal e-commerce, focusing on domestic transactions rather than cross-border trade. Although the study of digital technology in halal trade has expanded, a significant research gap remains. These studies tend to focus more on aspects of halal regulation and certification, while the role of digital technologies, such as blockchain and e-commerce, in facilitating global halal product trade remains less noticeable.

Therefore, this study aims, first, to analyze the existing literature on the role of digital ecosystems in supporting global halal product trade and, second, to identify the main challenges faced in its implementation. By understanding these dynamics, the results of this research can contribute to the development of more effective policies and strategies in utilizing digital technology to accelerate the growth of halal product trade globally.

METHOD

This study employs a qualitative approach, utilizing a literature review method, to analyze various sources on the role of digital ecosystems in global halal product trade (Sugiyono, 2003). Data collection is conducted through documentation by browsing relevant literature in academic databases, such as ScienceDirect and Google Scholar. To increase validity, data triangulation was carried out by comparing various sources and methods. Data analysis uses content analysis techniques to identify patterns, trends, and relationships between the digital ecosystem and global halal trade. The information is categorized based on key themes, including certification transparency, supply chain efficiency, and challenges. With this approach, the research is expected to provide a comprehensive understanding of the role of digital technology in halal trade, identifying opportunities and challenges in its implementation.

RESULT AND DISCUSSION

A. The Role of the Digital Ecosystem

The development of the digital ecosystem has brought a breath of fresh air to the world of trade, including in the halal product sector, which is now increasingly global. With the presence of digital platforms, the production, distribution, and marketing process of halal products can be carried out more efficiently and reach the global market. Information technology enables halal businesses to expand their consumer reach across geographical boundaries, as well as enhance connectivity between producers, distributors, and consumers.

One concrete example is the existence of Halal-based e-commerce platforms**,** such as HalalStreet UK, Zilzar, and Halal Trading, which allows halal MSMEs in Southeast Asia to market their products to the European and Middle Eastern markets. In this context, e-commerce not only serves as a means of buying and selling but has evolved into a halal digital ecosystem that integrates the principles of sharia maqashid into its operations. The concept of Sharia e-commerce is a Sharia-based digital market innovation with an international scope, where anyone can open an online store and reach buyers from various countries, provided that the products sold are halal certified (Imani et al., 2022).

The transformation towards digitalization also has an impact on the cost efficiency of business interactions. Seller and buyer interactions become faster, cheaper, and more flexible. This condition creates new opportunities, especially for halal products, to enter the global market that was previously inaccessible to small and medium-scale business actors (SMEs). This model promotes broader market inclusion by utilizing Sharia-based online marketplaces that cater to global Muslim consumers with specific halal needs and standards. More than just trade, this digital ecosystem also serves as a means of education and the dissemination of Sharia economic values. By providing information about the principles of sharia, including maqashid and halal product education, digital platforms also increase consumer awareness of the quality and halal status of a product. The existence of halal e-commerce allows consumers from various parts of the world, including non-Muslims, to buy halal products with a sense of security and trust.

Implementing a digital ecosystem based on Islamic principles requires a robust security system. Digital systems are prone to cyberattacks, which can compromise user trust due to technological vulnerabilities and the risk of data breaches. The protection of user data is crucial for maintaining privacy and preventing financial losses. Data protection in sharia digital transactions is an integral part of the principles of security and privacy in sharia (Hamsin et al., 2023). Blockchain technology is recommended for its ability to improve the traceability and validation of transaction data.

Additionally, the risk of fraud in the Islamic digital payment system is a significant concern. There is a need to implement stringent security measures to prevent unauthorized actions that can compromise the system's integrity (Pochmara & Świetlicka, 2024). These efforts are crucial so that the digital system can operate optimally and provide users with trust and security.

Essential pillars of the global halal product trading ecosystem are trust and transparency, especially in cross-border digital contexts. Consumer trust is fostered through education and the involvement of respected Islamic figures in promoting Sharia-compliant services, such as Islamic e-wallets (Mauris, 2024). Transparency—particularly via technologies like blockchain—enhances traceability and certifies compliance with halal standards. Halal authorities are increasingly standardizing certification to strengthen public confidence (Halal Food Council, 2024). Ethical principles such as honesty and accountability underpin the halal supply chain, ensuring both legality and spiritual integrity (Ramlli et al., 2024). Recent disruptions have shown that lack of transparency erodes consumer trust, making it imperative to align Islamic ethics with technological innovations (Adnan, 2025). Together, trust and transparency are vital for sustaining halal commerce globally.

B. Digital Innovation in Supporting Global Halal Product Trade

1. Blockchain in the Halal Assurance System

Blockchain is a technology that functions as a system for recording digital currency transactions without the need for third-party involvement, such as banks. The system is managed collectively by its users. For example, when five individuals want to make transactions without going through an intermediary institution, every transaction they make will be recorded in a digital ledger that can be accessed and monitored in real-time by all network members (Bagraff et al., 2024).

This technology offers significant benefits in storing permanent and openly accessible data. When integrated with the halal industry, blockchain has great potential to increase added value through enhanced product transparency and traceability, particularly in the food and beverage sector. This allows anyone to search for the halal status of the product thoroughly. This transparency is created because data and transactions are stored in a distributed network that can be accessed by anyone who has permission or access to the system (Maulani et al., 2023). The use of blockchain technology in halal product trading has significant potential to enhance transparency, security, and reliability in the halal food supply chain system.

Few companies have initiated the integration of blockchain technology into the halal product supply chain to enhance transparency, traceability, and consumer trust. Masverse, a Malaysian blockchain firm, developed MasChain to ensure end-to-end traceability of halal products, aligning with Shariah compliance from farm to table. The platform utilizes smart contracts and IoT integration to automate certification and monitor product conditions in real time (Sadasivan, 2024). In the United States, HalalTrace has introduced a blockchain solution specifically designed for halal food, integrating with certifiers such as ISA. Their platform enables small businesses to track meat and processed goods affordably. A 2024 pilot with a New York halal butcher implemented QR-code tracking, which reportedly reduced consumer complaints about authenticity by 40% (Adnan, 2025). Fluree, a U.S.-based company, partnered with Malaysia's Sinisana Technologies to leverage blockchain for halal beef verification. Their collaboration aims to provide transparency throughout the lifecycle of halal food products, ensuring compliance from cattle to grocery store shelves (Johnson, 2022).

Blockchain technology is being increasingly adopted in Indonesia’s various industries to enhance transparency and efficiency. For instance, PT Sreeya Sewu Indonesia Tbk has implemented a Halal Blockchain system in its Belfoods product line, ensuring that every stage of chicken processing—from slaughtering to packaging—complies with Islamic Sharia principles. Consumers can access detailed information about the halal certification process via QR codes on product packaging, fostering trust and confidence in product authenticity (Sidarto & Hamka, 2021).

In countries where halal certification focuses solely on the final product, there is a heightened risk of inconsistencies and fraud due to varying interpretations of halal standards across different stages of the supply chain. Indonesia, adhering to a stringent "zero tolerance" policy, prohibits any presence of non-halal elements throughout the production process. To uphold this standard, blockchain provides a decentralized and transparent system that records each transaction and process step, ensuring traceability and integrity throughout the entire supply chain. This approach aligns with the principles of Maqasid al-Shariah, emphasizing the protection of religion, life, intellect, lineage, and property (Qanita et al., 2024).

2. Integration of IoT in Halal Product Supervision and Management

The Internet of Things (IoT) has emerged as a pivotal technological advancement in enhancing the supervision, verification, and traceability of halal products across the food, pharmaceutical, and cosmetic sectors. In the context of halal supply chains, IoT enables the real-time monitoring of environmental conditions, such as temperature, humidity, and contamination risks, during transportation and storage—crucial elements in preserving the halal integrity of products. Such monitoring ensures compliance with Sharia principles throughout the logistics process rather than relying solely on end-product verification (Harsanto et al., 2024; Wong et al., 2024).

In the pharmaceutical and cosmetics industries, IoT systems automate the collection and analysis of ingredient data to verify that raw materials are free from substances that are haram or najis. These capabilities not only support halal certification but also enhance efficiency by reducing human error and expediting the decision-making process (Masood et al., 2023). Furthermore, IoT reduces operational costs and accelerates time-to-market by streamlining production and distribution workflows (Wan-Chik et al., 2023).

A leading example is PT Sreeya Sewu Indonesia Tbk, which integrates IoT sensors with data analytics and machine learning through its Smart Farm system. This platform monitors livestock

conditions—such as health, behavior, and coop temperature—optimizing fan controls to ensure animal welfare and hygiene standards. The system's consistent data collection supports both quality assurance and compliance with halal requirements while also enabling collaboration with local farmers to elevate agricultural productivity and sustainability (Sreeya, 2025).

3. Technology Digital Twin

Digital twin technology is revolutionizing the halal supply chain by providing virtual replicas of physical systems, enabling real-time monitoring, predictive analytics, and enhanced transparency. These digital models integrate data from IoT sensors to simulate and analyze the performance of products and processes, ensuring compliance with halal standards throughout the supply chain (Liu et al., 2021).

A study by Apandi and Ibrahim (2025) highlights the application of digital twin technology in various multinational companies to enhance transparency, traceability, and compliance in halal supply chains. For instance, Nestlé utilizes digital twins to monitor production and distribution processes in real-time, ensuring adherence to halal standards from raw material selection to packaging, thereby preventing cross-contamination and fostering consumer trust in regions such as the Middle East and Southeast Asia.

DHL utilizes digital twin technology to manage the delivery of halal products, particularly in the food and pharmaceutical sectors, by digitally tracking environmental conditions such as temperature and humidity during transportation, thereby ensuring compliance with halal principles (FreightAmigo, 2025). Unilever utilizes digital twins to monitor the supply chain of halal cosmetic products, tracing the origins of ingredients and production processes to ensure the absence of non-halal elements, thereby guaranteeing product transparency in markets across the Middle East and Asia.

Johnson & Johnson integrates digital twin technology in the halal pharmaceutical supply chain to verify that all active ingredients and excipients are free from non-halal substances, maintaining product stability during international shipping. Almarai, a prominent food company in the Middle East, utilizes digital twins in its production processes, spanning from farming and slaughtering to milk processing and distribution, ensuring that each product batch meets halal criteria and is free from contamination (Al-Balwy, 2024; Hanaysha, 2023).

Compared to other technologies, such as blockchain and RFID, digital twins offer a unique advantage by providing an interactive, comprehensive, and real-time view of the entire supply chain, facilitating dynamic monitoring and predictive analytics. The integration of digital twin technology in the global halal industry promises increased transparency, reduced counterfeiting risks, and optimized logistics performance, paving the way for more efficient and trustworthy halal certification processes worldwide (Apandi & Ibrahim, 2025).

The integration of Digital Twin in the global halal industry promises to increase transparency, reduce the risk of counterfeiting, and optimize logistics performance. For halal certification bodies, this technology presents opportunities for implementing digital audits and real-time verification that are faster and more accurate. Along with the widespread adoption of this technology, uniform global halal certification standards may be formed in various countries and industrial sectors.

4. Big Data and Artificial Intelligence (AI)

The integration of Big Data analytics is revolutionizing manufacturing strategies by enabling companies to analyze market trends and consumer behaviors, thereby predicting future demands. These predictive capabilities are essential for strategic planning and resource allocation, allowing manufacturers to stay ahead in a competitive market (Vasilopoulou et al., 2023). In the realm of business and marketing, many companies leverage Big Data to gain insights into market trends and

customer behaviors. By analyzing data from online platforms, social media, and customer interactions, businesses can tailor their products to meet customer needs better (Badshah et al., 2024).

The future points towards an increased integration of Big Data with Artificial Intelligence (AI). AI algorithms, particularly deep learning, enable systems to learn patterns from data without requiring extensive human intervention, allowing them to operate autonomously. AI also facilitates large-scale data management, offering recommendations or actions based on analytical outcomes. This synergy between Big Data and AI has broad applications, ranging from the development of autonomous vehicles to early disease detection (Cudjoe et al., 2024). AI's potential lies in its ability to process vast datasets and uncover hidden patterns that are not easily discernible by humans. Technologies like machine learning and deep learning are pivotal in generating predictions and recommendations based on historical data. For instance, in e-commerce, AI can analyze extensive data to provide product suggestions aligned with consumer preferences (Theodorakopoulos & Theodoropoulou, 2024).

Recent research underscores the pivotal role of Big Data analytics in enhancing retail market trend predictions and operational efficiency. By employing advanced techniques such as machine learning and data mining, retailers can gain profound insights into consumer behavior, anticipate market shifts, and formulate more targeted business strategies. These data-driven approaches enable companies to respond swiftly to changing consumer demands and optimize their operations accordingly. For instance, a study by Ajiga et al. (2024) highlights how Big Data analytics facilitates precise market trend forecasting and consumer behavior analysis, thereby empowering businesses to make informed decisions and maintain a competitive edge in the dynamic retail landscape.

A key finding from the study is the improved accuracy of market trend predictions. Unlike traditional methods that rely on limited historical data, Big Data facilitates large-scale, real-time analysis. This capability enables companies to respond to market dynamics and make informed decisions swiftly. However, achieving optimal results necessitates comprehensive integration, including infrastructure readiness and skilled human resources (KBV Research, 2025).

C. Challenges of the Digital Ecosystem in Global Halal Product Trade

In the digital era, halal trade holds significant potential for growth through the effective utilization of digital technologies. Digitalization within the halal trade ecosystem can enhance efficiency, transparency, and market access for both producers and consumers. However, implementing a digital ecosystem in halal trade faces several challenges that need to be addressed promptly.

Lack of a unified global standard for halal certification. Different countries have their own halal certification bodies and standards, such as JAKIM in Malaysia, MUI in Indonesia, and the Saudi Food and Drug Authority (SFDA) in Saudi Arabia. This disparity often leads to mutual non-recognition of halal certificates, posing significant obstacles to cross-border trade. Businesses are compelled to adapt their products to meet multiple standards simultaneously, increasing complexity and costs. Efforts to harmonize these standards are essential for facilitating smoother international halal trade (Othman & Ibrahim, 2025).

The limitation of digital infrastructure in many developing countries, particularly in regions of South Asia, Africa, and parts of Southeast Asia. Challenges such as uneven internet access, slow connectivity, and a lack of necessary hardware and software impede the digitalization process (Iswenda, 2024). These infrastructural deficiencies hinder the adoption of digital solutions in the halal trade sector, affecting efficiency and competitiveness.

The lack of Sharia e-commerce regulation means that a Sharia-based digital ecosystem still requires a robust legal framework. The absence of a Sharia e-commerce regulatory body that can supervise digital business practices from the perspective of Sharia maqashid is one of the loopholes that irresponsible parties can exploit. As a result, non-halal products or unethical practices are still often found on online trading platforms (Imani et al., 2022).

Lack of technology integration with Sharia principles. Many digital platforms still use conventional systems that are not in line with Sharia principles, such as the use of interest-based models or speculative systems (gharar) in financing. This raises concerns for Muslim consumers who wish to maintain the integrity of their transactions (Ribadu et al., 2020).

Consumer perception of halal product authenticity. Consumer skepticism about halal authenticity, especially in online markets, is a significant concern. Studies highlight that fraudulent halal certifications and mislabeling have eroded consumer trust. For instance, research indicates that many Muslim consumers are not well-informed about their rights and the legal protections related to halal products, making them vulnerable to fraud. Another study emphasizes that the rise of food fraud in the halal supply chain has led to increased consumer awareness about the importance of product authenticity and the provenance of halal products (Voak, 2021).

Shortage of skilled human resources in it and digital trade. The digital divide in developing countries contributes to a shortage of skilled human resources in information technology (IT) and digital trade. A report by the IEEE Communications Technology Update highlights that the digital divide impacts life in developing countries by limiting access to modern technology and hindering economic advancement (Kloza, 2023). Additionally, the United Nations has noted that a widening digital divide and lagging internet use in developing countries threaten to leave these states behind in technological progress (United Nations, 2023).

Complexities in payments and international transactions. Cross-border transactions involving halal products face challenges due to variations in currencies and regulatory issues. The adoption of digital payment platforms, while helpful, introduces complexities. For example, the development of Shariah-compliant e-commerce payment processing methods aims to address issues such as *riba* (interest) and *gharar* (uncertainty) while ensuring transaction security (Amboala et al., 2015). Furthermore, platforms like PayHalal offer Shariah-compliant payment solutions, ensuring that transactions are free from interest and uncertainty (PayHalal, 2017).

Scalability limitations in blockchain technology. Blockchain scalability is a pressing issue, particularly as transaction volumes continue to increase. Limited block sizes can lead to delays in transaction processing. To address this, innovations like sharding technology are being explored. Sharding divides the blockchain into smaller parts, enabling the parallel processing of transactions and thereby enhancing scalability (Vezgo, 2024). Another study examines the evaluation of sharding algorithms and the prospects for decentralized data storage to enhance scalability and security in blockchain networks (Bulgakov et al., 2024).

To address the challenges faced, governments, companies, and other stakeholders must collaborate in developing solutions that maximize the benefits of digitalization and e-commerce while mitigating their associated risks and negative impacts. Governments must play a crucial role in developing policies that support the innovation and adoption of new technologies. Strengthening digital infrastructure is also crucial for navigating the digital era, including the development of reliable telecommunications infrastructure, a secure digital payment system, and robust cybersecurity. The role will help create an environment conducive to the sustainable growth of halal product trade in this digital age. Additionally, it is crucial to provide training and education to the workforce in order to address the challenges and capitalize on the opportunities that emerge in the digital economy (Anggraeni, 2024).

The transformation of global halal product trade through digitalization and e-commerce brings great potential for the growth and progress of the global economy. However, to realize this potential, close cooperation between governments, companies, and other stakeholders is necessary, along with the development of robust digital infrastructure and investment in human resources. In this way, it can be expected that global halal product trade will continue to grow and thrive in this digital age, providing greater benefits to all parties involved.

CONCLUSION

This research confirms that the digital ecosystem plays a crucial role in supporting the global trade of halal products. Digital technology has enabled halal business actors, particularly small and medium-sized enterprises (SMEs), to access the global market with greater efficiency through the use of e-commerce, blockchain-based supply chain integration, and connectivity between businesses and halal certification bodies.

In terms of technological innovation, this study identifies various digital solutions that support the integrity and efficiency of halal product trading. Among them are Blockchain, which strengthens the transparency and traceability of halal certification; Internet of Things (IoT), which enables real-time monitoring in production and distribution processes; Digital Twin, which improves quality control and verification in the supply chain; Big Data and Artificial Intelligence (AI), which help analyze market trends and consumer preferences.

However, the challenges faced in the implementation of the halal digital ecosystem are still quite complex, including the disharmony of halal certification standards between countries, the limitations of digital infrastructure in various regions, the lack of sharia e-commerce regulations, the lack of integration of digital technology with sharia principles, the low digital literacy of human resources, the complexity of international transactions, and technical limitations such as the scalability of blockchain. To optimize this potential, close collaboration among governments, industry players, certification bodies, and digital platforms is necessary, including the development of inclusive digital infrastructure and the strengthening of human resource capacity. With an integrated and participatory approach, the digital ecosystem can serve as a primary catalyst in enhancing the competitiveness of halal products in the global market in a sustainable manner, aligning with Sharia principles.

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