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Role of Halal Digital Ecosystem and Msmes Strengthening in Jepara Toward Sustainable Economy in Industry 4.0

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Abstract

This study examines the low level of digital literacy and limited understanding of halal certification among MSMEs in Jepara Regency and how this affects their ability to effectively utilizehalal certification in the digital era. This issue is highlighted by the low level of knowledge and use of halal certification among MSMEs in Jepara, both in understanding the certification process and in using it as a business development strategy.

The findings indicate that government initiatives to promote digital transformation and halal certification have not yet been fully effective due to limited digital skills, inadequate human resources, and continued reliance on manual processes. Advances in Industry 4.0 technology and digital marketing have created opportunities for small and medium sized enterprises (SMEs) to increase their competitiveness and expand their market reach however, in practice, small businesses still face several challenges, particularly limited business funding, high halal certification costs, and difficulties in product packaging.

The study also shows that collaboration among public institutions, certification facilitators, cooperatives, and MSMEs actors has strong potential to build an integrated digital halal ecosystem that supports business sustainability and regional economic development. This research provides a conceptual framework linking digital capability, certification readiness, and institutional collaboration as key drivers of MSMEs competitiveness. This framework provides a practical contribution to Jepara Regency in developing a digital based halal ecosystem strengthening strategy to enhance MSMEs competitiveness and market access.

Keywords: *Halal Digital Ecosystem, MSMEs, Sustainable Economy, Industry 4.0, Jepara*

Introduction

Over the past two decades, global economic development has experienced significant growth, which has also influenced the development of Islamic economics and finance at both national and international levels. According to the *State of the Global Islamic Economy Report 2020–2021*, Indonesia ranked fourth in the global halal food sector and third in the halal fashion sector, reflecting a notable improvement in its global position (Uncertainty, 2020). The rapid advancement of digital technologies, such as the Internet of Things (IoT), Big Data, Artificial Intelligence (AI), and digital platforms, has further transformed business processes by improving efficiency and expanding market access (Kgakatsi et al., 2024). In

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the context of the development of the digital economy, the concept of halal is not only seen as a religious aspect but also as a set of principles based on Islamic law that regulatethe production, distribution, and consumption processes (Rahman et al., 2023). As consumer demand for halal products increases, it comes from both Muslim and non Muslim consumers since halal products are know for their high quality, transparency, and production process (Anggraeni et al., 2024).

In Indonesia, this growing awareness has encouraged the rapid expansion of the halal industry, positioning the country as one of the largest halal consumer markets globally, with total halal product consumption reaching approximately US$144 billion (Kasnelly, 2023). Despite this potential, the integration of halal micro, small, and medium enterprises (MSMEs) into the digital halal ecosystem remains limited. The digital halal ecosystem refers to an interconnected system involving digital technologies, halal regulations, certification bodies, Islamic finance, digital marketing platforms, and consumers within a unified halal value chain (Kurniawan dkk., 2021). One of the main challenges faced by MSMEs is the low level of digital literacy and limited understanding of halal certification, which hinders their ability to fully benefit from digital transformation (Putri dkk., 2025)

Central Java Province is among the regions experiencing rapid growth in halal-based MSMEs. By 2024, the number of MSMEs in Central Java exceeded 4.2 million units, with approximately 36% operating in the halal food and beverage sector (Ministry of Cooperatives and SMEs, 2024). However, the adoption of halal certification and digital technology remains relatively low, with only a small proportion of MSMEs holding halal certificates (Cahya, 2024). This condition indicates the need for strengthening the halal digital ecosystem to enhance MSMEs competitiveness and sustainability. Jepara Regency represents one of the regions in Central Java with significant MSMEs growth, particularly in the processed food, furniture, and creative industries. Although the number of MSME workers continues to increase annually, their contribution to labor absorption relative to the total population has declined. This trend indicates weakening MSMEs performance and highlights the urgency of strengthening MSMEs through digitalization and innovation to support sustainable economic development.

Table 1

Labor Absorption in the MSMEs Sector in Jepara Regency

YEAR	LABOR ABSORPTION	NUMBER POPULATION	PERCENTAGE
2021	213,485	1,188,510	17.96%
2022	213,605	1,192,811	17.91%
2023	215,371	1,264,598	17.03%
2024	218,355	1,283,687	17.01%

Sumber: Jepara Regency Cooperatives (2024)

According to the data in the table above, the number of MSMEs workers reached 213,485 in 2021 and increased slightly to 213,605 in 2022. A more notable increase occurred in 2023, when the number rose to 215,371. This positive trend continued in 2024, with the number of workers reaching 218,355, an increase of approximately 2,984 compared to the previous

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year. However, despite the continuous growth in the number of workers, the contribution of MSMEs to the total population declined annually, from 17.96% in 2021 to 17.91% in 2022, 17.03% in 2023, and 17.01% in 2024. This indicates that although both the MSMEs workforce and the population in Jepara have increased each year, the proportion of labor absorption relative to the population has decreased. Consequently, the role of MSMEs in labor absorption has weakened, highlighting the need to strengthen MSMEs through digitalization and innovation to enhance their contribution to employment.

Based on the above background, the problems addressed in this study are formulated as follows: (1) MSMEs in Jepara Regency have not optimally utilized digital halal certification and Industry 4.0 technologies due to low literacy and limited technical support; (2) access to halal digital platforms and online certification remains limited, affecting MSMEs competitiveness and sustainability; and (3) the halal value chain has not been efficiently integrated with technological innovation, hindering the realization of a sustainable economy in the Industry 4.0 era. This study aims to analyze the factors causing the suboptimal use of the halal digital ecosystem by MSMEs in Jepara Regency, identify barriers to ecosystem integration, and examine the role of the halal digital ecosystem in enhancing MSMEs competitiveness and sustainability. The findings are expected to provide benefits for policymakers, MSMEs practitioners, and academics by offering insights into strengthening MSMEs and supporting sustainable regional economic development.

Previous studies have highlighted the importance of digitalization in strengthening halal MSMEs. Ardiansyah., dkk (2025) emphasized the role of Sharia-compliant e-commerce in expanding market access, while Nugroho (2022) identified digitalization as a key factor in maintaining MSMEs sustainability. Other studies have shown that Industry 4.0 technologies, digital literacy, and halal literacy significantly influence MSMEs performance and consumer trust (Kamila, 2023; Putri et al., 2025; Haque, 2021). However, most of these studies examine these factors separately and have not comprehensively examined how the halal digital ecosystem cotributes to strengthening MSMEs at the regional level. Therefore, this study aims to analyze the role halal digital ecosystem in strengthening MSMEs towards economic sustainability in the Industry 4.0 era, specifically in Jepara Regency.

Theoretically, the halal digital ecosystem integrates concepts of digital transformation, halal value chains, and sustainable economic development. Digital transformation enables MSMEs to improve efficiency, expand markets, and enhance competitiveness, while halal certification ensures compliance with Islamic principles and builds consumer trust (Budi Harsanto et al., 2024). Strengthening MSMEs through an integrated halal digital ecosystem is therefore essential for achieving sustainable economic growth in the Industry 4.0 era. Overall, this study fills a research gap by examining the halal digital ecosystem as an integrated system that supports MSMEs empowerment and sustainable economic development at the regional level. By focusing on Jepara Regency, this research is expected to contribute both theoretically and practically to the development of halal economic models in Indonesia.

Literature Review

Sustainable Development Theory

Sustainable Development Theory was introduced by the World Commission on Environment and Development, which defined sustainable development as meeting

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present needs without compromising the ability of future generations to meet their own needs (WCED, 1987). This concept emphasizes the integration of economic, social, and environmental dimensions. The framework was further strengthened by Elkington's Triple Bottom Line approach, which evaluates sustainability based on the balance between social well-being, environmental protection, and economic growth (Elkington, 2001). Globally, the perspective was reinforced through the 2030 Agenda for Sustainable Development, which established 17 Sustainable Development Goals and highlighted the importance of technological innovation, inclusive growth, strong institutions, and environmental protection as interconnected pillars of sustainability (United Nations, 2015). In the context of the halal industry, digitalization such as halal certification systems, Islamic fintech, and integrated halal supply chains has been identified as a key driver of MSMEs competitiveness and sustainable industry development (Bank Indonesia, 2020). Thus, sustainable development theory provides a conceptual foundation for understanding digital halal transformation as part of inclusive and environmentally responsible regional economic growth. In the modern era, construction is increasingly linked to digital tranformation that increases economic efficiency and business models (Ferreira dkk., 2022). Digital technology also increases business productivity and promotes inclusive economics for MSMEs. while integrating technological innovation and keberlanjutan strategies promotes economic growth (Geogre dkk., 2020).

Halal Digital Ecosystem

The halal digital ecosystem is an integrated system that combines the halal industry, digital technology, and economic platforms to enhance efficiency, transparency, and competitiveness in halal product production and distribution (Amalia & Maksum, 2025). It connects stakeholders such as MSMEs, certification bodies, logistics providers, and consumers through digital marketplaces that support traceability, certification compliance, and sharia-compliant transactions (M. Kurniawan et al., 2025). This ecosystem expands market access, simplifies certification processes, and strengthens digital marketing, thereby improving MSMEs competitiveness and supporting sustainable economic development in the Industry 4.0 era (Efendi et al., 2024; Dupi & Baloch, 2025).

MSMEs

Micro, small, and medium enterprises (MSMEs) are defined based on criteria such as capital, turnover, number of employees, and type of economic activity, as well as characteristics including small production scale, limited resources, restricted market access, and local business orientation (Lubis et al., 2021). MSMEs play a vital role as major employment generators and pillars of regional economies, particularly in the digital transformation era, where adaptation involves not only technology adoption but also changes in business models and digital literacy among entrepreneurs (Panduwinata et al., 2025). Their integration with the halal digital ecosystem can increase income, create decent jobs, and promote environmentally responsible production, demonstrating how digital and halal-based approaches can strengthen MSMEs sustainability and competitiveness (Mahaitin H. Sinaga et al., 2024). Regional data indicate that more than 47,000 MSMEs operate across various industries, contributing significantly to workforce development and creative productivity (Suhodo, 2022). However, major challenges remain, especially limited

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digital capability and technology utilization in production and marketing processes, making digital transformation essential for improving productivity and supporting inclusive, ethical, and progressive economic development in the Industry 4.0 era (Kartini, 2023; Rahma et al., 2025).

Industry 4.0 and Digital Transformation

Industry 4.0 refers to the integration of advanced technologies into business and manufacturing systems to create more digital, interconnected, and automated production and supply chain processes (Francisco et al., 2024). Digital transformation, meanwhile, is a strategic process in which organizations adopt digital technologies to reshape business operations, workflows, customer interaction, organizational structures, workforce skills, and business models (Kraus et al., 2021). Empirical studies indicate that adopting Industry 4.0 elements can enhance MSMEs productivity, operational efficiency, and environmentally sustainable practices, particularly when supported by gradual implementation, training, and policy support (Costa et al., 2023). These technologies also contribute to sustainable development by improving resource efficiency, reducing waste, and increasing supply chain transparency, while enabling better measurement and reporting of sustainability performance (Li et al., 2025). Local evidence from Jepara shows that digital marketing adoption, such as in small-scale banana chip enterprises, can expand market reach and reduce dependence on traditional distribution channels; however, limited digital literacy and financial capacity remain key barriers, highlighting the importance of institutional support, training, and cross-sector collaboration to maximize MSMEs readiness in the Industry 4.0 era (Noviawati, 2024; Chaidir et al., 2024).

Research Methodology

This study uses a deskriptif kualitatif approach with a case study methodology to understand the phenomenon of digital literacy and the use of halal certification in MSMEs thisapproach is used to illustrate social phenomena based on informational perspectives in the field (Furidha, 2023). while case study methodology is used to investigate phenomena in a way that is relevant to everyday life (Rusdy dkk., 2024). This approach was selected because it enables the exploration of experiences, perspectives, and field phenomena that cannot be adequately explained through quantitative data (Cypress, 2015). Informants is gathered by selecting MSMEs users in regency Jepara who are easily identified by researchers and available as information. Responses are obtained from business owners that have experience using digital technology as well as understanding or experience with halal certification. Convenience sampling is a sampling technique based on ease of access for the researcher, in which respondents are chosen because they are readily available, considered relevant to the research objectives, willing to provide data, and meet the predetermined criteria established by the researcher (Sari et al., 2018).

The selection criteria included specific requirements. For government agencies and institutions: (1) direct involvement in MSMEs digitalization programs and access to relevant policy or data, (2) location or operational presence in Jepara with informed consent, and (3) ability to participate in in-depth interviews with knowledge of halal digital ecosystems or MSMEs digitalization. For MSMEs: (1) registered and active halal-sector businesses, (2) owners with operational experience capable of explaining technology use, challenges, and opportunities, and (3) utilization of halal digital ecosystem elements such as halal

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marketplaces, digital certification, payment systems, or traceability features. Informants consisted of a representative from the Cooperative and MSMEs Office, a representative from a halal certification organization, and two MSMEs actors involved in the halal digital ecosystem.

Data were collected through observation, interviews, and documentation. Interviews were conducted to obtain detailed insights into the use of halal digital ecosystems, challenges encountered, and MSMEs empowerment processes. Observations were used to assess MSMEs operational conditions, digital technology adoption, and security aspects. Documentation provided supporting data from archives, reports, policies, and official records related to MSMEs and the halal ecosystem in Jepara.

Data validity was ensured through triangulation techniques. Source triangulation compared information from MSMEs, government agencies, and certification institutions. Method triangulation combined interview results, observations, and document analysis to obtain a comprehensive understanding of the phenomenon. Researcher triangulation was conducted through cross-interpretation of interview findings with supervisors and peers to minimize subjective bias. Data analysis followed the interactive model of Miles and Huberman (1994), Paradigm, which consists of data reduction, data appearance, and conclusion /verification. In the data reduction phase, researchers select data from observations, interview, and documentation that are relevant to digital literacy, halal certification, and UMKM development in Jepara. Data is then presented in a descriptive manner to examine the relationship between the digital halal ecosystem and UMKM strengthening, and it is interpreted in a comprehensive manner.

This analytical framework ensured consistency, reliability, and rigor in interpreting the research findings, enabling the study to provide meaningful insights into the role of digital ecosystems in strengthening MSMEs and advancing economic development in the Industry 4.0 era.

Result and Discussion

Implementation of Digital Halal Certification and Industry 4.0 Technology among MSMEs

The study's findings indicate that Government Regency Jepara has started implementing the digital transformation of MSMEs through the formalization of business operations and the use of digital public services, particularly through the Business Identification Number (NIB) that is managed through the OSS platform. Ownership NIB is crucial for MSMEs students to gain access to several government programs, such as halal certification and other digital training. This policy encourages the government to integrate MSMEs into a more formal, transparent, and technologically based economic system.(OECD, 2020). The results of the interview with the Department of Cooperatives, SMEs, Manpower, and Transmigration of the Regency Jepara, as well as the halal certification support agency (LP3H Puspelindo) and the MSMEs, which is supported by documentation of socialization and companion activities

However, the findings of this study also indicate that the implementation of digital halal certification in Jepara MSMEs is still not running smoothly. Several structural and technical issues are still being discussed, particularly regarding the digital literacy of MSMEs employees in accessing halal-certified platforms, such as SIHALAL or PTSP Halal, from

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the account creation process, business data analysis, to document creation. According to halal certification assistants, more than 80% of MSMEs users still experience difficulties using digital systems independently, requiring direct assistance. This situation is characterized by the characteristics of MSMEs, which are mostly home-based businesses with entrepreneurs who have been in business for more than 40 years, as well as a lack of technological advancement. Aside from this, other certification procedures are still carried out by hand, such as the process of testing products using a health service, which requires business owners to bring samples to the lab. As a result, the anticipated digitalization process can increase efficiency, but it has not yet reached its full potential, and the use of digital certification is still heavily dependent on the facilitator or companion process. According to earlier research, the effectiveness of digitalization implementation at MSMEs may be hampered by the disparity between digital capabilities and the environment of the organization these initiatives, the utilization of digital halal certification remains sub optimal. (Khan dkk., 2020).

From a institutional perspective, the digital platform for halal certification aims to increase transparency, traceability, and administrative efficiency in the certification process. However, the effectiveness of its implementation greatly depends on user capabilities and technological proficiency. The study's findings indicate that this system does not function as a digital mechanism that is beneficial to MSMEs. Based on the results of the interview with companion halal and MSMEs in Regency Jepara, many business owners particularly those in the micro and home industries still struggle to understand and operate the system because of factors like age, educational background, limitations of digital literacy, and access to technology and infrastructure. The aforementioned situation indicates that digital certification is currently more important as a supporters system that requires assistance from government agencies and companion bodies in order to reduce the disparity between available digital systems and user capabilities. This situation highlights the transitional phase in the digital transformation process of MSMEs, rather than permanent institutional dependence. It also highlights the first step towards digital transformation, which requires increasing technological literacy, technical proficiency, and digital infrastructure development an institutional perspective, digital halal certification platforms are designed to improve transparency, traceability, and administrative efficiency. However, their effectiveness depends largely on users technological readiness. Many MSMEs, particularly micro-scale and home-based enterprises, face difficulties in understanding and operating online systems due to age, educational background, and limited access to digital infrastructure. Consequently, digital halal certification functions primarily as an assisted system rather than a fully autonomous digital service for MSMEs, consistent with previous findings on digital divides in MSME development (UNCTAD, 2021).

In other ways, MSMEs adoption of industry 4.0 technology primarily through digital marketing, e-commerce platforms, and social media creates opportunities to reduce market size and increase business productivity. According to Rachmawati dkk. (2021), digital platforms enable UMKM users to reach a more expansive consumer base outside of local marketplaces and reduce reliance on traditional distribution channels. However, the increase in exposure in relation to the digital market also occurs when new developments include intensification of sales, more aggressive pricing strategies, and an increase in

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branding, packaging, and product quality. Because of this, the success of integrating industry 4.0 technology and halal digital certification at MSMEs is not limited to the availability of digital systems, but also to the expansion of business owners' digital capabilities so they can use technology effectively and continuously.

MSMEs with limited capital, inadequate product standardization, and weak branding capabilities encounter difficulties in sustaining competitiveness within digital markets. These findings suggest that digital transformation and halal certification cannot function effectively as standalone policies. Without adequate capacity building, financial support, and product development, MSMEs are unable to fully benefit from digitalization, a conclusion that aligns with ecosystem-based approaches to MSMEs digital development (Ismail et al., 2018).

Although this study uses the Industry 4.0 conceptual framework, empirical research shows that its implementation at the MSMEs level is more successful in the form of digital market integration through online sales, social media use, and e-commerce platform utilization. This situation can be explained by the characteristics of MSMEs, which typically have financial resources, technological capabilities, and digital infrastructure. As a result, the adoption of new technologies, such as the Internet of Things (IoT), production automation, or data analytics, is relatively limited. Therefore, in the early stages of digital transformation, MSMEs tend to adopt technologies directly related to market access, product promotion, and customer network needs. In this context, the concept of industry 4.0 is not only manifested via the transformation of production technology but also through the digitalization of commercial and distribution activities that enable business owners to engage with a more expansive digital economy. In this way, the digital integration carried out by MSMEs can be viewed as a first step toward the adoption of industry 4.0, where digitalization of the market serves as a precursor to the development of more complex technologies in production and business management. This approach is in line with MSMEs digital transformation literature, which emphasizes digital market integration as the first step towards the industry 4.0 ecosystem. MSMEs limited modalities, unacceptable product standardization, and weak branding capabilities make it difficult to overcome competitiveness in the digital market. This indicates that digital transformation and halal certification cannot function well as self-contained policies. According to Ismail dkk (2018), MSMEs cannot fully benefit from the advantages of digitalization if it does not increase its capacity for adequate, financial support, and product development. This is a challenge that goes hand in hand with an ecosystem based approach to digital MSMEs development.

Role of the Halal Digital Ecosystem in Strengthening MSMEs Competitiveness

The results demonstrate that collaboration among government agencies, halal certification institutions, cooperatives, and MSMEs has begun to form a halal digital ecosystem in Jepara Regency. This ecosystem facilitates MSMEs' access to halal certification, strengthens institutional coordination, and enhances consumer trust in halal-certified products. Previous studies emphasize that halal certification plays a strategic role in strengthening product credibility and reducing information asymmetry between producers and consumers (Tieman, 2017). The halal digital ecosystem contributes to MSMEs competitiveness by integrating legality, quality assurance, and digital market access. MSMEs that obtain halal certification experience improved acceptance in modern retail channels and digital

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marketplaces, where product safety, religious compliance, and transparency are increasingly valued by consumers (Wilson & Liu, 2011). As a result, halal certification serves not only as a religious obligation but also as an economic instrument that enhances market positioning.

In this study, the concept of competitiveness MSMEs is not only understood normatively but also operationalized through a few empirical indicators that emerge from interview results and field observations. First, competitiveness is reflected in increased market access, especially when MSMEs products that have been certified halal have more opportunities to be sold in more lucrative distribution channels, such as online stores, digital marketplaces, and modern retailers that ensure product legality. Furthermore, competitiveness is also evident in the increase in consumer trust, where the presence of a halal label provides assurance of quality and adherence to religious standards, hence influencing consumers' preferences when choosing products. Third, competitiveness indicators are listed in product standards and legality, as the halal certification process encourages MSMEs to improve business administration, raw materials, and production processes to comply with established standards. Fourth, in some recent cases, it is also related to the ability of MSMEs to use digital marketing tools, such as social media and e-commerce platforms, which enable the need to expand consumer reach beyond the local market. Thus, in the context of this research, increasing MSMEs competitiveness is understood as a combination of market access requirements, consumer trust, regulatory requirements and product standardization, and the ability to utilize digital ecosystems for marketing and distribution activities.

However, the benefits of this ecosystem are unevenly distributed. Differences in digital literacy, access to capital, and strategic orientation result in varying levels of ecosystem utilization among MSMEs. Enterprises with higher technological capability and stronger financial resources are better positioned to optimize digital platforms, while others remain dependent on offline markets and institutional facilitation. This situation indicates that the effectiveness of using the digital ecosystem is not only affected by technological factors, but also by a combination of structural factors such as modal capabilities, educational attainment, business acumen, and MSMEs business strategy. This finding supports earlier research indicating that digital ecosystems may unintentionally widen inequality among MSMEs if inclusivity is not prioritized (Nambisan et al., 2019). Institutional support therefore plays a critical role in mitigating these disparities. Government agencies and halal-support institutions act as intermediaries by providing guidance, technical assistance, and administrative facilitation. Without sustained institutional involvement, the halal digital ecosystem risks becoming exclusive and reinforcing existing structural weaknesses among micro-scale MSMEs.

Integration of the Halal Digital Ecosystem toward Sustainable Economic Development

Digital ecosystem integration contributes to economic development through a few mechanisms that may be empirically measured at the MSMEs level. First, this integration encourages business formalization, which is based on increasing Business Identification Number (NIB) and business legality as a prerequisite to obtain halal certification. This formalization allows MSMEs to access government programs, research, and more extensive marketing networks. Second, halal certification creates a need for market access, mostly

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because products that have already complied with halal standards are easier to obtain in stores thanks to modern regulations and digital platforms that promote product legality. This contributes to the stability of business operations since MSMEs users are not limited to local or traditional sales instead, they can sell their products through a variety of more accessible distribution channels (Hassan & Lewis, 2007). In addition, the increase in consumer trust in halal certified products also has an impact on the product reputation and customer satisfaction, which ultimately strengthens the business in the long term.

Nevertheless, several challenges continue to hinder full integration. Traditional business mindsets, limited technological capability, and resistance to regulatory change remain significant obstacles. Some MSMEs actors perceive halal certification and digital platforms as administrative burdens rather than strategic investments, reducing their motivation to engage fully in digital transformation. Similar patterns have been observed in other developing regions undergoing MSMEs digitalization (World Bank, 2020).

The findings highlight that sustainable integration requires a holistic approach that combines digital infrastructure development, human resource capacity building, and supportive regulatory frameworks. Training programs, continuous mentoring, and ecosystem-based assistance are essential to transform MSMEs mindsets and improve digital readiness. Moreover, consistent policy implementation and institutional synergy are necessary to ensure that halal digital initiatives contribute effectively to regional economic development and sustainability.

Discussion

This study confirms that digital halal certification functions both as a regulatory mechanism and as a strategic tool for MSMEs development in the Industry 4.0 era. Digitalization enhances efficiency, transparency, and accountability in the certification process while simultaneously strengthening business legitimacy and consumer trust. These findings are consistent with previous studies emphasizing the importance of digital transformation and institutional support in halal MSMEs development (Khan et al., 2020; Tieman, 2017).

This study shows that digital certification serves not only as a regulatory mechanism but also as a strategic tool for MSMEs development in the Industry 4.0 age. Increased digitalization can increase efficiency, transparency, and accessibility in the certification process, as well as increase business legitimacy and customer trust. This is in line with earlier research that highlights the importance of digital transformation in increasing the competitiveness of halal MSMEs, particularly through the need for market access, operational efficiency, and customer connection (Khairiah et al., 2025). In addition, digitalization also contributes to lowering marketing costs and improving business networks, even though there are still issues with digital literacy and business owners (Hediansyah dkk., 2022). However, in contrast to previous research that tends to overlook the benefits of digitalization in general, this study indicates that the integration of digital halal ecosystems and institutional support has a more comprehensive role in improving halal certification and MSMEs. This confirms earlier findings that the implementation of halal digital certification still faces a number of challenges, including technological literacy, administrative constraint, and the decline of business owners (Yuanitasari et al., 2025). In other contexts, research on digital platforms reveals that although platforms such as marketplaces and delivery order services do not strictly require halal certification, they do

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have significant potential to enhance the perception of certification through education, facilitation, and industry collaboration (Firdaus dkk., 2022). In light of this, compared to previous research, this study makes a new contribution by highlighting the importance of the convergence of digitalization, halal certification, and the institutional ecosystem as a foundation for MSMEs economic growth. This further strengthens the argument that optimizing the digital halal ecosystem will not only increase MSMEs economic productivity but also contribute to the development of the halal industry through the integration of Islamic law and technological innovation (Kamil dkk., 2024).

Furthermore, the results demonstrate that the halal digital ecosystem should be understood as a systemic framework integrating technology, regulation, and institutional collaboration. Digital platforms alone are insufficient to improve MSMEs performance without parallel investment in human capital development and financial accessibility. Limited digital literacy and unequal access to resources can significantly reduce the effectiveness of digital halal initiatives and exacerbate disparities among MSMEs (Nambisan et al., 2019). The findings also underline the importance of inclusivity in digital transformation. Micro-scale MSMEs are particularly vulnerable to digital exclusion if targeted assistance and mentoring are absent. Therefore, strengthening institutional roles and fostering inclusive ecosystem-based collaboration are essential to ensure that halal digitalization contributes to equitable and sustainable regional economic development. Overall, the integration of digital halal certification within a supportive ecosystem enhances MSMEs competitiveness, promotes business sustainability, and supports long-term economic resilience. However, continuous policy refinement, institutional coordination, and capacity building remain critical to maximizing its impact in the context of Industry 4.0.

Conclusion

This study concludes that a digital ecosystem plays a strategic role in strengthening micro, small, and medium enterprises (MSMEs) and advancing regional economic development in the Industry 4.0 era, particularly in Jepara Regency. The digitalization of halal certification functions not only as a formal legal requirement but also as a strategic instrument for enhancing consumer trust, expanding market access, and improving the professionalism of MSMEs operations. The involvement of institutional actors such as local governments and halal support institutions emerges as a critical determinant in building an ecosystem that enables MSMEs to adapt more systematically to halal regulations and digital technologies. The integration of the halal digital ecosystem, encompassing certification processes, digital marketing, and institutional assistance, demonstrates substantial potential in strengthening competitive advantage and supporting sustainable regional economic growth.

Nevertheless, the findings also indicate that the implementation of the digital ecosystem continues to face significant challenges. Limited digital literacy among MSMEs actors, constrained access to capital, and insufficient human resource readiness to adopt Industry 4.0 technologies remain major barriers. These constraints have resulted in the suboptimal and, in many cases, partial utilization of digital halal technologies and certification systems. Accordingly, the digital transformation of MSMEs should not be viewed solely as a technological shift, but rather as a broader process of structural and organizational change. This process requires continuous institutional support, transformation of business

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mindsets, and the implementation of inclusive and adaptive policies that are responsive to local conditions.

This study offers theoretical, practical, and policy-relevant contributions to the strengthening of the halal digital ecosystem as a driver of economic growth. From a theoretical perspective, it enriches the concept of the digital ecosystem by integrating halal-oriented business practices into the discourse on MSMEs digital transformation. Practically, the findings provide guidance for MSMEs and digital platforms in developing halal-based digitalization strategies that enhance consumer trust and market competitiveness. From a policy perspective, this study offers insights for the government and the Halal Product Assurance Organizing Agency (BPJPH) in optimizing the implementation of digital-based halal certification and regulatory frameworks. The primary contribution of this research lies in the development of a conceptual framework for the halal digital ecosystem, supported by empirical evidence from regional MSMEs, serving both as an academic reference and as a strategic foundation for practitioners in strengthening the halal economy. These results are reinforced by the findings of (Syarofi dkk., 2025) which show that competitiveness is reflected in increased market access, increased consumer trust, product standardization and legality, and the ability of MSMEs to utilize digital marketing channels.

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