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HALAL REIMAGINED: IR4.0 TECH DRIVES SUSTAINABILITY AND INCLUSIVITY IN ISLAMIC MONETARY ECONOMICS

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ABSTRACT

The expanding Halal sector, anticipated to reach USD 3.6 trillion by 2026, presents a significant opportunity to promote inclusive and sustainable economic growth based on Islamic values. Nevertheless, the industry faces challenges in achieving operational efficiency, ensuring transparency, and promoting financial inclusion. Industry 4.0 (IR4.0) technologies—namely Blockhain, Artificial Intelligence (AI), and the Internet of Things (IoT)—offer innovative solutions to address these issues. These technologies optimise resource utilisation, enhance operational transpacrency, and foster customer trust by ensuring compliance with Halal and ethical standards. This study underscores the importance of integrating IR4.0 technologies into the Halal industry with Islamic Monetary Economics (IME) principles, particularly in promoting financial inclusion, ethical procurement, and sustainability. Employing the Triple Bottom Line (TBL) framework, this study integrates Economic Sustainability (Financial Inclusion), Social Equity (*Maslahah*), and Environmental Stewardship (*Tayyib*) into a comprehensive model that connects IR4.0 technologies with the *maqasid* al-Shariah. By prioritising the preservation of faith, life, intellect, progeny, and wealth, this model positions the Halal industry as a global leader in ethical and sustainable economic development. This study employs a qualitative research design, appropriate for addressing the selected research topics and issues. The findings highlight the urgent need for stakeholders—businesses, regulators, and consumers—to embrace technological innovations and adapt to the evolving global commerce landscape. By taking proactive measures, stakeholders can harness IR4.0's potential to shape a prosperous and inclusive future for the Halal industry and its communities. Ultimately, this study emphasises the sector's potential to drive economic growth, social equity, and environmental sustainability, shaping a more inclusive and prosperous future for the communities it serves.

Introduction

The Halal industry is experiencing remarkable expansion, driven by the growing global Muslim demographic and increasing awareness of ethical consumption practices worldwide (Qotadah et al., 2022; Mustafid et al., 2024). According to a 2023 report by Salaam Gateway, the global Halal market is anticipated to attain a value of USD 3.78 trillion by 2028 (Salim et al., 2023). The latest report indicates that in 2022, the global population of 2 billion Muslim consumers spent approximately USD 2.29 trillion across various sectors, including food, pharmaceuticals, cosmetics, fashion, travel, and media/recreation. The dynamics of these industries are significantly shaped by the Islamic ethical consumption requirements. The data further highlights a 9.5%, year-on-year growth, increasing from USD 2 trillion in 2021, illustrating the rapid expansion of the Islamic economy. Notably, the appeal of the Halal market is expanding beyond Muslim consumers, attracting non-Muslims who resonate with its ethical economic principles. This shift signifies a transformation in consumer preferences, with a growing inclination toward products and services that adhere to Islamic principles while also appealing to a wider demographic seeking ethical and sustainable alternatives (Billal et al., 2020). This trajectory of growth alighns closely with the foundational principles of Islamic Monetary Economics (IME), which emphasise the importance of financial inclusion, resource efficiency, and the pursuit of social justice (Hotman, 2024).

The Halal industry has broadened its horizons, extending its influence beyond food and beverages to encompass finance, travel, fashion, and cosmetics, as noted by the World Halal Council in 2024. The presence of more than 1.8 billion Muslims across the globe (PRRI, 2023) presents a distinctive opportunity for the promotion of inclusive and sustainable development on a global scale. Nevertheless, to fully realise its potential, the Halal industry must embrace Industry 4.0 (IR4.0) technologies. Innovations associated with the Fourth Industrial Revolution—including Blockchain, Big Data Analytics, and Artificial Intelligence (AI)—offer significant opportunities for transformation. These advancements can enhance transparency, improve operational efficiency, and promote inclusivity within the Halal supply chain, as noted by Yaqub and Alsabban in their 2023 study. Blockchain technology, with its secure and immutable ledger system, plays a pivotal role in ensuring Halal compliance, thereby enhancing consumer trust (Novianti et al., 2020). Big Data Analytics enables the processing of vast data sets, providing valuable insights that enhance sourcing and logistics management (Barbosa et al., 2018). Moreover, AI optimizes production methodologies, tailors consumer interactions, and drives product innovation (Wan et al., 2020).

The integration of IR4.0 technologies will be effectively guided by the Triple Bottom Line (TBL) methodology, which serves as an exemplary framework for this research. The TBL approach synthesises the Halal industry with IME by focussing on three fundamental dimensions: Economic Sustainability, encompassing Financial Inclusion; Social Equity, represented by the concept of *Maslahah*; and Environmental Stewardship, characterized by the principle of *Tayyib*. Within this framework, IR4.0 technologies serve as key facilitators, enchancing operational efficiency, increasing transparency, and ensuring alignment with Islamic principles. Despite these advancements, a considerable research gap remains in exploring the intesection between IR4.0 technologies, the growth of the Halal industry, and the core values of IME. Zaidi (2020) highlights the limited scholarly attention devoted to this significant intersection.

In order to address the identified gap, this study presents the following research questions:

i. How can the implementation of IR4.0 technologies enchance operational efficiency, transparency, and financial inclusion within the Halal industry?

ii. in what ways can the TBL methodology align the Halal industry's practices with the fundamental principles of IME?

iii. How can IR4.0 technologies contribute to Economic Sustainability, Social Equity, and Environmental Stewardship within the Halal sector?

This study examines these inquiries by applying the TBL methodology and leveraging IR4.0 technologies to assess their role in advancing the Halal industry. Simultaneously, it advocates for IME principles, including financial inclusion, resource optimisation, and social justice.

Literature Review

The global Halal industry is experiencing phenomenal growth, driven by two powerful factors: a burgeoning Muslim population exceeding 1.8 billion (PRRI, 2023; Worldometer, 2024) and a paradigm shift toward ethical consumption (Billah et al., 2020). This expansion has transcended its traditional focus on food and beverages, now encompassing a diverse range of products and services, including travel, finance, fashion, and cosmetics (Azam & Abdullah, 2020). Significantly, this growth represents more than mere religious compliance. It reflects a growing global consciousness, where consumers increasingly prioritize goods that align with ethical and sustainable principles (Chukwu et al., 2023). This dynamic industry intersects with IME, a distinctive economic framework rooted in Islamic values (Hassan et al., 2021; Kader et al., 2021; Iqbal & Mirakhor, 2017). IME emphasizes financial inclusion, resource efficiency, and social justice, serving as a blueprint for sustainable development (Zarrouk, 2015). By aligning with these core principles, the Halal industry has the potential to become a powerful catalyst for achieving these objectives.

The Halal industry's alignment with IME is far from coincidental, as financial inclusion, a cornerstone of IME, is actively promoted through the growth of the Halal industry. The rising demand for Halal products and services creates new market opportunities, enabling the inclusion of unbanked or underbanked populations, particularly in Muslim-majority countries (Iqbal & Mirakhor, 2017). Resource efficiency, another core tenet of IME, is deeply embedded within the Halal industry. Emphasis on ethical sourcing, and responsible production practices, often required by Halal guidelines, naturally supports resource efficiency objectives (Abdelrahman et al., 2021). Additionally, IR4.0 technologies, such as Big Data analytics, empower businesses to enhance resource utilization across the Halal supply chain (Abdelrahman et al., 2021). Finally, social justice, a core fundamental principle of IME, is actively promoted by the Halal industry's emphasis on fair labor practices and the ethical treatment of animals (Ali & Rizwan, 2023). Additionally, the industry's focus on inclusivity—catering to a diverse Muslim population with varying economic backgrounds—fosters social justice by ensuring equitable access to essential goods and services.

Growth and Scope of the Halal Industry

The expansion and diversification of the Halal business have been influenced by a multifaceted interaction of demographic, cultural, and economic elements (Iswanto, 2023). The global Muslim population, now surpassing 1.8 billion (PRRI, 2023; Worldometer, 2024), forms the foundation of this market, with a growing demand for Halal-compliant products and services reflecting a widespread commitment to Islamic principles across various industries. A 2023 report by Salaam Gateway projects that the global Halal market will reach valuation of USD 3.78 trillion by 2028 (Salim et al., 2023). Additionally, the emergence of a Muslim middle class in regions such as Southeast Asia and the Middle East has substantially enhanced purchasing power, further driving this growth (Masood et al., 2023). Beyond Muslim demographics, there has been a significant global shift toward ethical and ecological consumption, leading to rising interest in Halal products among non-Muslim consumers (Ali & Rizwan, 2023).

The Halal industry's scope has expanded beyond traditional sectors such as food and beverages, now encompassing banking, travel, fashion, and medicines (Azam & Abdullah, 2020). Halal tourism projects in non-Muslim countries such as Japan and South Korea exemplify the industry's ability to adapt to global cultural shifts while addressing the needs of consumer demographics (SGIER, 2022). These advancements underscore the Halal industry's unique role in promoting cross-cultural economic interactions and promoting sustainable economic growth in both Muslim-majority and non-Muslim countries. As a result, the growth trajectory of the Halal industry highlglights its importance not only in serving Muslim consumers but also in influencing broader consumer trends and driving economic prosperity across varied geographical and cultural landscapes.

IME: A Framework for Ethical and Sustainable Development through the TBL

The current global economic system is often criticized for perpetuating inequality, environmental harm, and ethical shortcomings. IME offers a principled alternative, grounded in Islamic values, addressing these challenges by prioritizing equity, sustainability, and ethics in financial systems (Iqbal & Mirakhor, 2017). IME's alignment with the TBL framework, introduced by John Elkington in 1994, creates a powerful synergy for redefining economic success (Figure 1). While the TBL emphasizes the three dimensions of sustainability—people (social equity), planet (environmental stewardship), and profit (economic viability)—recent advancements, such as proposal by Hamidi and Worthington (2023) to introduce a fourth dimension, "Prophet," reflect the incorporation of Islamic values into sustainability discourse. These integrations signal the potential for the TBL framework to evolve further, particularly within Islamic contexts.

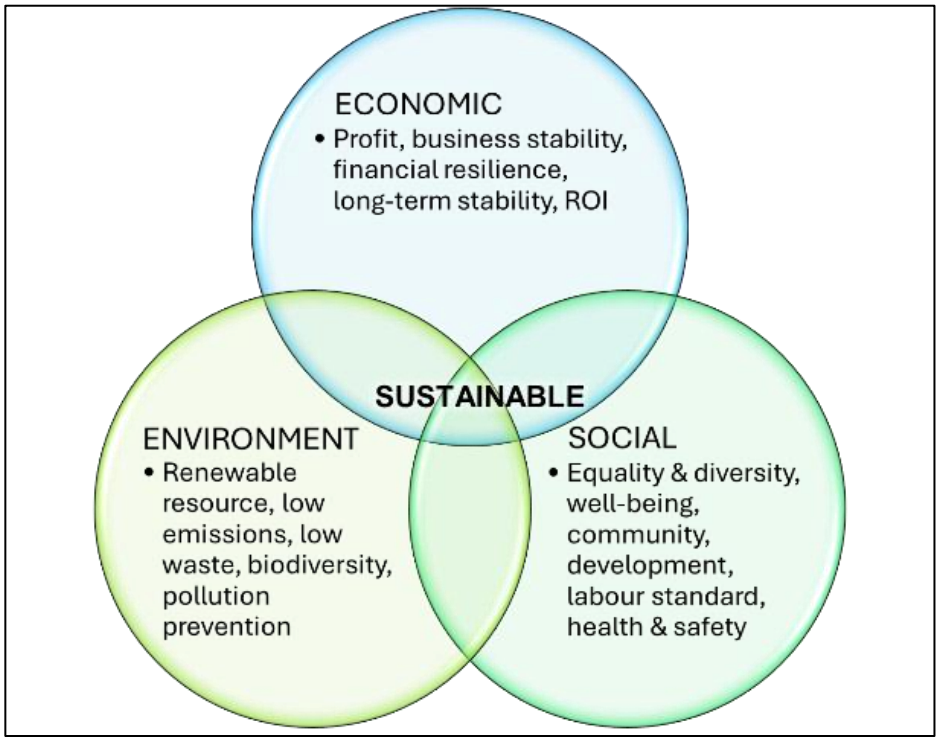

Figure 1. The TBL Framework from Evans (2017)

Social / People: Financial Inclusion and Social Equity

IME places significant emphasis on promoting inclusivity and social justice, mirroring the "people" dimension of the TBL. By rejecting *Riba* (interest), IME advocates for equitable financial mechanisms such as *Mudarabah* (profit-sharing partnerships) and *Musharakah* (joint ventures). These instruments ensure the fair distribution of risks and benefits, fostering cooperative financial systems (Iqbal & Mirakhor, 2017). Ethical alternatives like *Sukuk* (Islamic bonds) and *Murabaha* (cost-plus financing) further empower underserved communities, ensuring their access to financing (Mahamud, 2019). Additionally, mechanisms such as *Zakat* (mandatory almsgiving) and *Waqf* (endowments) redistribute wealth, creating social safety nets that directly benefit marginalized populations (Samad, 2019). Despite its theoretical robustness, empirical research validating the social impacts of IME remains limited. While studies often emphasize its conceptual benefits, there is a notable lack of comprehensive data measuring reductions in inequality or tangible improvements in the financial well-being of marginalized communities. This gap highlights the need for evidence-based evaluations, especially in rural regions where traditional banking systems are often ineffective.

Environment / Planet: Resource Efficiency and Environmental Stewardship

The principle of *Khilafah* (trusteeship) serves as the foundation of IME's environmental focus, underscoring humanity's responsibility to safeguard natural resources for future generations. IME promotes sustainable consumption and production practices, discouraging waste and fostering ecological balance (Chaudry, 2022). The Halal industry exemplifies these values through ethical sourcing, humane animal treatment, and sustainable supply chain management. However, the industry faces challenges in empirically validating its environmental claims. While theoretical frameworks by Ali and Rizwan (2023) emphasize sustainability, operational data quantifying environmental benefits—such as reductions in carbon footprints or conservation of biodiversity—remain scarce. Moreover, the lack of standardized metrics to measure these impacts further complicates the Halal industry's position as a model for ecological responsibility.

Economic / Profit: Ethical Economic Growth

IME redefines economic growth by embedding ethical considerations into profitability. Unlike conventional systems, which often prioritize short-term gains, IME encourages long-term stability through Shariah-compliant instruments. These include profit-sharing mechanisms that discourage speculative activities and promote genuine investments in productive sectors (Ibrahim & Alam, 2018). The adoption of modern technologies like Blockchain has further enhanced transparency in IME-aligned industries, particularly the Halal sector. Blockchain facilitates trust and traceability, which are crucial for global market expansion (Novianti et al., 2020). However, controversies have emerged regarding the environmental costs of Blockchain, including its high energy consumption, which appears to contradict IME's sustainability objectives. Addressing these contradictions will be critical to aligning technological innovations with IME's ethical and environmental goals.

Integrating the TBL into IME: Synergies and Challenges

Although IME and the TBL share complementary objectives, their integration faces significant hurdles. Variations in Islamic jurisprudence (*Fiqh*) across regions lead to inconsistent applications of IME principles, particularly in the context of Halal certification and Shariah compliance (Yakar, 2021). These disparities create tensions between strict ethical adherence and pragmatic economic goals, posing challenges for IME's scalability in global markets. Furthermore, empirical limitations in validating IME's impacts—whether social, environmental, or economic—hinder its acceptance as a universal model. While frameworks like the Hamidi and Worthington' (2023) extension of TBL toninclude the dimension of "Prophet" demonstrate theoretical alignment, practical implementation remains underexplored. To bridge these gaps, more rigorous research is essential to measure IME's effectiveness in achieving TBL sustainability goals across diverse contexts.

In conclusion, the principles of IME, viewed through the lens of the TBL framework, offer a holistic model for ethical and sustainable economic development. By focusing on social equity, environmental stewardship, and economic growth, IME has the potential to transform the global economic landscape, presenting a viable alternative to conventional systems. Future research should focus on empirical evaluations of IME's impact across these dimensions to further refine its integration into diverse economic contexts. Moreover, the Halal industry's rapid expansion necessitates innovative solutions, such as leveraging technology, to address inconsistencies in certification and ensure compliance with both ethical and environmental standards.

Alignment of the Halal Industry with IME

IME represents a transformative economic framework that emphasizes equity, sustainability, and ethical principles. The alignment between the Halal industry and IME underscores a mutual focus on promoting financial inclusivity, resource efficiency, and ethical consumption (Iqbal & Mirakhor, 2017; Masood et al., 2023). While this synergy is promising, a closer analysis of existing research reveals gaps, inconsistencies, and challenges that merit critical examination.

A key area of agreement among scholars is IME's focus on eliminating *Riba* (usury) and promoting profit-sharing mechanisms, such as *Musharakah* and *Mudarabah*, to align stakeholder interests (Saratian et al., 2022). These principles align seamlessly with the Halal industry's ethical focus, which promotes fairness and mutual benefit. However, while these mechanisms are theoretically robust, empirical studies on their practical application within the Halal sector remain limited. For instance, there is a lack of case studies evaluating the impact of profit-sharing on businesses operating in Halal-certified industries, particularly in regions where Islamic finance systems are underdeveloped.

Similarly, while IME advocates for financial inclusion, research on its effectiveness in addressing socio-economic inequalities within Muslim and non-Muslim communities is scarce. Abdullah and Oseni (2017) argue that Shariah-compliant financial products empower Muslim consumers, but questions remain about their accessibility for marginalized populations. For example, limited adoption of Islamic finance in rural areas suggests barriers such as low financial literacy and inadequate infrastructure, which require further investigation.

In terms of resource efficiency, IME's principles resonate with the Halal industry's focus on sustainability and ethical sourcing. However, existing literature often potrays this alignment as more aspirational than evidenced. While the Halal industry has made strides in minimizing waste and ensuring humane treatment of animals, inconsistencies in enforcement across regions and industries persist (Chaudry, 2022). Future studies should critically assess whether the Halal industry's sustainability practices are universally applied or vary based on local interpretations of Islamic law.

Challenges in integrating IME principles into the Halal industry highlight significant gaps. One key issue is the diversity in *Fiqh* (Islamic jurisprudence) interpretations, which complicates the establishment of uniform Halal certification standards (Yakar, 2021). While some scholars advocate for international frameworks, limited research has critically assessed their feasibility across different cultural and regulatory contexts. Additionally, although Blockchain technology has been proposed as a mean to enhance transparency and traceability (Novianti et al., 2020), its implementation within the Halal industry remain sparse. Investigating the scalability of these technologies and their potential to address discrepancies in Halal certification processes warrants further exploration.

To advance this field, future research must adopt a more critical lens, questioning the assumptions and methodologies underpinning current studies. Key areas include evaluating the real-world application of IME principles in the Halal sector, identifying barriers to financial inclusion, and examining regional disparities in sustainability practices. Additionally, interdisciplinary collaboration among economists, technologists, and Islamic scholars could provide innovative solutions to longstanding challenges, such as achieving uniform certification standards and facilitating technological integration.

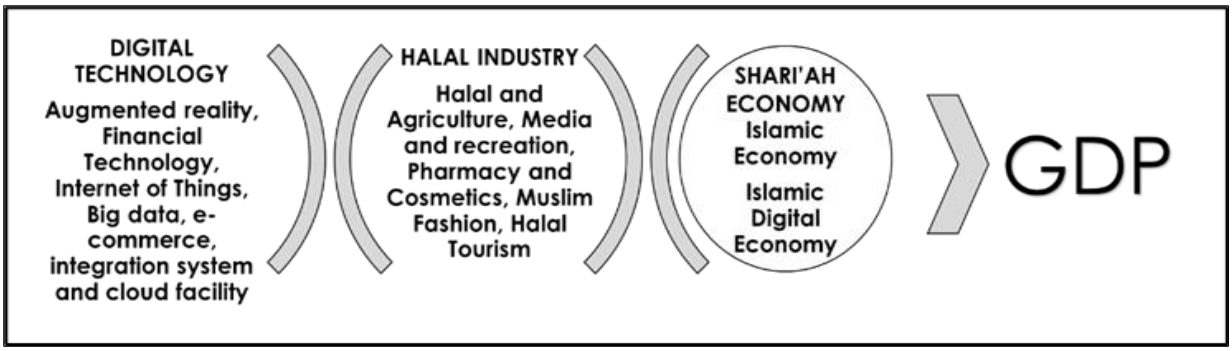

Figure 2. The Role of the Digital Economy in the Development of the Halal Industry and the Shari'ah Economy in Indonesia from Iskandar and Saputra (2023)

IR4.0, Halal Industry, and the Islamic Monetary Economy: A Symbiotic Relationship for Sustainable Growth

Embracing IR4.0 technologies is crucial for the Halal industry to unlock its full potential and contribute meaningfully to IME objectives. IR4.0 signifies the integration of cutting-edge technologies like Blockchain, Big Data analytics, and AI across various industries (Foenna et al., 2020). These innovations offer transformative opportunities for the Halal industry and ultimately IME, as described below:

i. Blockchain and Halal Supply Chain Assurance: Blockchain technology provides traceability and tamper-proof records of processes from raw material procurement to product delivery. Novianti et al., (2020) highlight its role in the Halal meat business to ensure compliance with Islamic slaughter requirements while fostering consumer trust. Hendayani et al. (2023) further explain how Blockchain promotes environmental sustainability by recording eco-friendly actions in Halal product production. Practical examples include systems that use Blockchain to verify real-time conformity to Halal rules, reducing fraud and strengthening supply chain integrity.

ii. Big Data Analytics for Risk Prediction and Optimisation: Big Data Analytics identifies compliance gaps and analyses operational patterns to mitigate hazards from escalating. Al-Garadi et al., (2020) discuss how real-time monitoring can help preserve Halal standards in cattle operations, lowering the likelihood of ethical violations. Furthermore, Chen et al., (2020) emphasise Big Data's importance in resource optimisation, hence promoting ecologically sustainable practices in the Halal food industry. These technologies are critical for improving resource allocation and minimising waste, which aligns with the Halal industry's overall sustainability aims.

iii. AI for Streamlining Halal Certification and Personalisation: AI simplifies halal certification by automating processes such as ingredient verification and document analysis, thereby reducing certification timelines while maintaining accuracy replacing manual processes (Bakar et al., 2019). Alam et al., (2022) emphasise AI's ability to personalize consumer experiences by adapting marketing campaigns to Halal-specific tastes, hence increasing engagement. Furthermore, Sharma et al., (2021) demonstrate that intelligent certification systems can procatively detect non-compliance trends, improving the reliability of Halal certifications.

iv. Enhancing Financial Inclusion with IR4.0 Technologies: Big Data Analytics and AI facilitate Shariah-compliant financing, notably for Halal-certified SMEs. Hassan and Ariff (2020) explain how data-driven credit scoring algorithms improve financial access for under-represented businesses. These developments are consistent with IME principles, which promote equitable economic growth and empower Halal enterprises.

v. Cross-Technology Synergy for Trust and Innovation: Prashar et al., (2020) demonstrate how combining Blockchain and Big Data has resulted in integrated systems for authenticating Halal claims. This cross-sectoral partnership capitalises on the capabilities of both technologies to develop trust, ensure transparency, and foster consumer confidence in Halal products.

The intersection of the Halal industry, IME, and IR4.0 technologies marks a transformative milestone, heralding a new era defined by transparency, innovation, and operational efficiency. By leveraging the capabilities of Blockchain, Big Data analytics, and AI, the Halal industry is uniquely positioned to meet the dynamic expectations of consumers while advancing the broader objectives of IME—including financial inclusion, ethical resource utilization, and social equity (Hameed et al., 2020). This synergistic relationship has the potential to drive sustainable and inclusive economic growth globally, fostering trust through transparency, empowering underserved populations, optimizing resources, and aligning consumption patterns with ethical principles. Moreover, this technological evolution not only enhances the Halal industry's global competitiveness of the Halal industry but also establishes it as a pioneering model of ethical and sustainable consumption for the modern era.

Research Methodology

This study employs a qualitative research design suited to addressing the selected research topics and issues. The chosen research strategy is a content analysis study that utilises secondary data acquired through document analysis. The objective of document analysis is to determine the substance and significance within the documents. This process involves collecting data from various reading materials, including books and journals published over the last decade, sourced from two prominent primary databases: Web of Science (WoS) and Scopus. Synchronously, Google Scholar was selected as a supporting database due to the relevance of the articles it contains. Ensuring that no critical papers were excluded from the review was considered essential (Gusenbauer, 2019; Halevi et al., 2017). Only articles and books containing empirical data were selected, as these publications feature original data and undergo rigorous peer review processes. This survey also omitted other types of document, such as review articles, books, book chapters, theses, and conference proceedings. Furthermore, only articles writted in English were selected, given the authors' linguistic proficiency, thereby mitigating the risk of misinterpretations during the analysis (Shaffril et al., 2021a, 2021b). The data acquired from document analysis is evaluated through a descriptive analysis method to evaluate the potential of IR4.0 technologies in augmenting the Halal sector's role in inclusive and sustainable economic development, in accordance with IME principles. There are five stages of research methodology applied as stated in Figure 3:

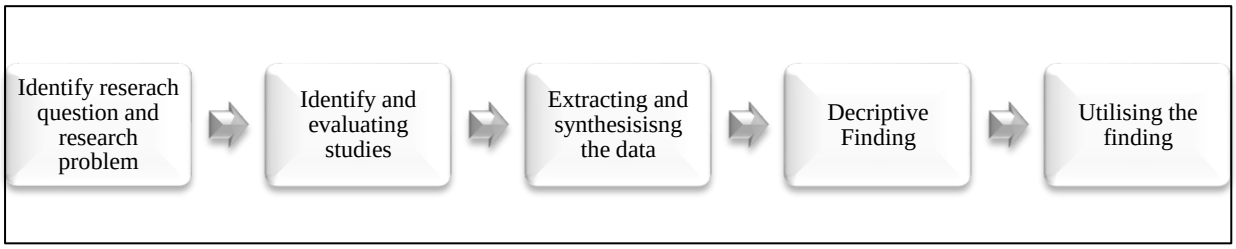

Figure 3. Process of research methodology

Findings

Implementation of IR4.0 Technologies in the Halal Industry

The adoption of IR4.0 technologies such as Blockchain, Big Data analytics, and AI demonstrates significant opportunities for enchancing operational efficiency, transparency, and financial inclusion within the Halal industry. Blockchain technology ensures immutable records, enabling transparent and traceable supply chains, which increase consumer confidence in Halal compliance (Novianti et al., 2020; Hendayani et al., 2023). This level of transparency fosters trust, which is essential for the industry's global expansion. Research by Prashar et al., (2020) has shown that Blockchain can effectively monitor and validate Halal standards throughout the supply chain, particularly in sectors like Halal meat production.

Big Data analytics offers tools to optimize production, monitor compliance, and reduce operational inefficiencies. Studies by Rejeb et al., (2021) and Al-garadi et al., (2020) highlight its capacity to process complex datasets for real-time risk management, reducing instances of non-compliance. Moreover, Big Data analytics empowers financial inclusion by providing Islamic financial institutions with data-driven insights to design Sharia-compliant financial products tailored to micro, small, and medium enterprises (Hassan & Ariff, 2020).

AI enhances both operational efficiency and compliance verification. AI-powered systems streamline the Halal certification process, reducing costs and minimizing human error (Bakar et al., 2019). Additionally, AI tools personalize marketing and consumer engagement strategies by analyzing behavioral data, creating deeper connections with Halal consumers (Alam et al., 2022).

Despite these advancements, the integration of IR4.0 technologies into the Halal industry faces significant challenges, including high implementation costs, limited technical expertise, and disparities in regulatory frameworks (Yakar, 2021).

Harmonizing the Halal Industry with IME through the TBL

The TBL framework, encompassing economic sustainability (profit), social equity (people), and environmental stewardship (planet), aligns seamlessly with the foundational principles of IME. This alignment provides a robust mechanism for harmonizing the ethical aspirations of the Halal industry with its operational practices.

1. Economic Sustainability: Shariah-compliant financial instruments, such as *Sukuk* and *Musharakah*, foundational to IME, echo the TBL's profit dimension by ensuring ethical growth. These mechanisms facilitate resource allocation for sustainable ventures while discouraging speculative activities (Ibrahim & Alam, 2018). Blockchain technology supports this by enhancing market trust and enabling transparent financial transactions, thus contributing to robust economic sustainability (Hendayani et al., 2023).

2. Social Equity: The prohibition of *Riba* and the encouragement of financial inclusion align with the TBL's emphasis on people. Instruments such as *Zakat* and *Waqf* reinforce communal welfare, addressing systemic inequities (Samad, 2019). Big Data Analytics further supports this equity by identifying underserved populations and enabling access to tailored financial services (Hassan & Ariff, 2020).

3. Environmental Stewardship: The TBL's planet dimension is reflected in IME's principles of *Khilafah*, emphasizing ethical resource management. The Halal industry's adoption of sustainable sourcing and production practices aligns with this goal. However, as Chaudry (2022) and Mahamud (2019) observe, empirical validation of these environmental claims remains scarce, necessitating further research to substantiate the industry's environmental contributions.

Facilitating Progress in Economic Sustainability, Social Equity, and Environmental Stewardship by Leveraging IR4.0 technologies

IR4.0 technologies play a transformative role in addressing the TBL dimensions within the Halal sector:

i. Economic Sustainability: AI and Blockchain enhance supply chain efficiency, reducing waste and costs while ensuring ethical compliance (Novianti et al., 2020). These technologies also streamline financial transactions, promoting economic inclusivity and market stability (Hendayani et al., 2023).

ii. Social Equity: Big Data and AI enable targeted outreach to marginalized communities, fostering inclusive growth. For instance, Al-garadi et al. (2020) highlight the use of real-time analytics in monitoring Halal compliance, ensuring fair access to ethically certified products and services.

iii. Environmental Stewardship: Blockchain ensures transparency in sourcing and production processes, aligning with IME's environmental principles. While theoretical models suggest significant potential for waste reduction and resource optimization, studies by Mahamud (2019) and Ali and Rizwan (2023) stress the need for operational metrics to effectively evaluate these impacts.

The integration of IR4.0 technologies into the Halal industry offers a dynamic pathway to operational efficiency, transparency, and inclusivity, thereby advancing the goals of IME. supported by the TBL framework, these technologies facilitate holistic progress in economic, social, and environmental dimensions. However, addressing challenges such as empirical gaps, inconsistent regulatory frameworks, and high adoption costs is critical for achieving sustainable growth and solidifying the Halal sector's position as a leader in ethical and sustainable consumption.

Discussions

The findings reveal that integrating IR4.0 technologies into the Halal industry represents a transformative opportunity to align its practices with the principles of IME while advancing the objectives of the TBL framework. This section delves deeper into these insights, addressing the research questions and proposing a conceptual framework to harmonize these elements.

Operational Efficiency, Transparency, and Financial Inclusion

The significance of IR4.0 technologies in improving operational efficiency and transparency in the Halal industry is evident through the utilization of Blockchain, Big Data Analytics, and AI. Blockchain's immutable ledgers establish an exceptional degree of transparency throughout supply chains, guaranteeing traceability and adherence to Halal requirements (Prashar et al., 2020; Hendayani et al., 2023). This cultivates consumer confidence while mitigating inefficiencies arising from non-compliance or fraud. Big Data analytics enhances this by providing detailed insights into sourcing, logistics, and production, facilitating real-time risk management (Rejeb et al., 2021).

AI further enhances operational efficiency by automating Halal certification and quality control operations, accelerating compliance assessments and minimising human error (Bakar et al., 2019; Alam et al., 2022). Notably, these technologies transcend internal efficiencies to promote financial inclusion. Technologies such as Big Data analytics and Blockchain are essential in facilitating Islamic financial institutions to create Shariah-compliant financing models specifically designed for small and medium Halal firms, hence addressing the unmet requirements of marginalized groups (Hassan & Ariff, 2020).

Harmonizing the Halal Industry with IME via the TBL Framework

The TBL methodology serves as a crucial link between the operational requirements of the Halal industry and the core concepts of IME. The concept of economic sustainability, reflected in IME's profit dimension, corresponds with Shariah-compliant financial instruments that foster ethical and equitable development (Ibrahim & Alam, 2018). The transparency of Blockchain and the accuracy provided by AI in certification processes bolster market trust and stability, hence strengthening the economic resilience of the sector.

The concept of social equity, reflected in TBL's people dimension, aligns with IME's focus on financial inclusion and community welfare. Big Data Analytics enables businesses to recognise disadvantaged demographics and ensure equal access to Halal-certified products and services (Hassan & Ariff, 2020). Moreover, technology such as AI and Blockchain can improve *Zakat* distribution and *Waqf* administration, ensuring that resources are allocated effectively to support public welfare and reduce poverty.

Environmental stewardship, or the planetary dimension of the TBL, is inherently connected to IME's ethical principles of *Khilafah* and resource conservation. Although Blockchain and Big Data can monitor and enhance resource utilization, hence fostering environmentally sustainable practices, existing research indicates that the full potential of these technologies in minimising waste and carbon emissions is still inadequately investigated (Ali & Rizwan, 2023; Mahamud, 2019). This highlights the necessity for additional empirical study to substantiate environmental assertions in the Halal sector. The integration of IR4.0 technologies with the TBL framework provides a definitive route to economic sustainability, social equality, and environmental stewardship. Blockchain promotes economic resilience by enhancing trust in financial transactions and certificates (Hendayani et al., 2023). AI customises consumer interaction, thereby expanding the market attractiveness and inclusivity of the sector (Alam et al., 2022).

Socially, Big Data Analytics facilitates targeted financial inclusion and aids in the formulation of equitable policies that tackle systematic disparities in Halal trade (Hassan & Ariff, 2020). Blockchain enhances traceability for sustainable sourcing, integrating the Halal industry's practices with global sustainability objectives (Novianti et al., 2020).

The intersection of IR4.0 technologies, the TBL framework, and IME principles signifies a pivotal moment for the Halal industry. The discourse underscores the transformative capacity of these technologies to enhance operational efficiency, promote transparency, and encourage inclusivity, while advancing the ethical objectives of IME. The findings from this study have culminated in the development of a novel TBL framework, specifically tailored for the Halal Industry and IME, as illustrated in Figure 4. This framework integrates economic sustainability, social equity, and environmental stewardship with the operational and ethical principles of the Halal industry, providing a comprehensive model for sustainable and equitable development.

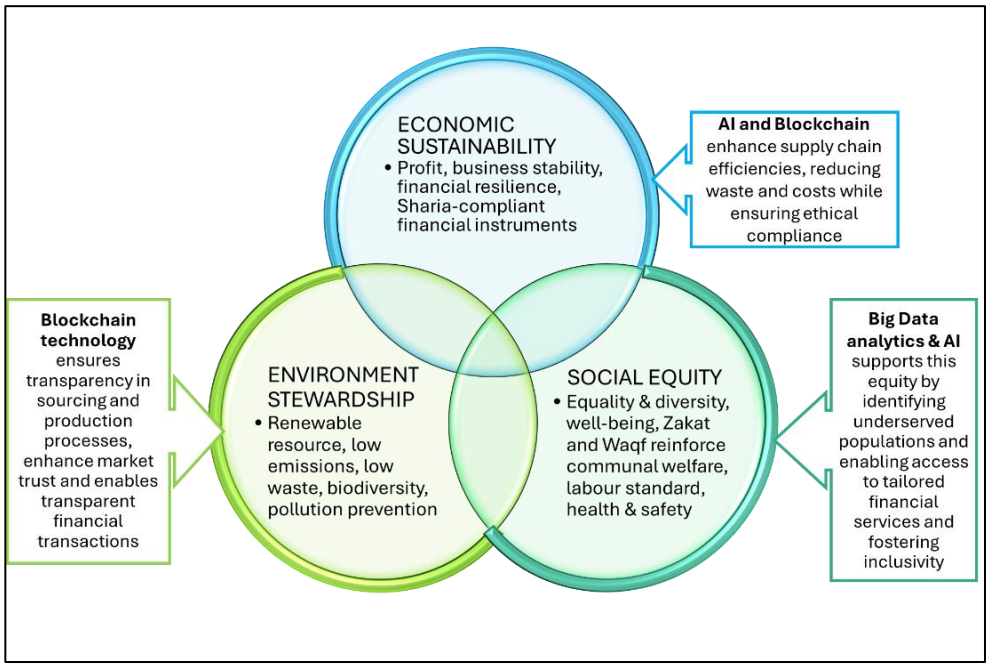

Figure 4. TBL Framework of Halal Industry and IME by Authors' own model that is an extension of Evans (2017) framework

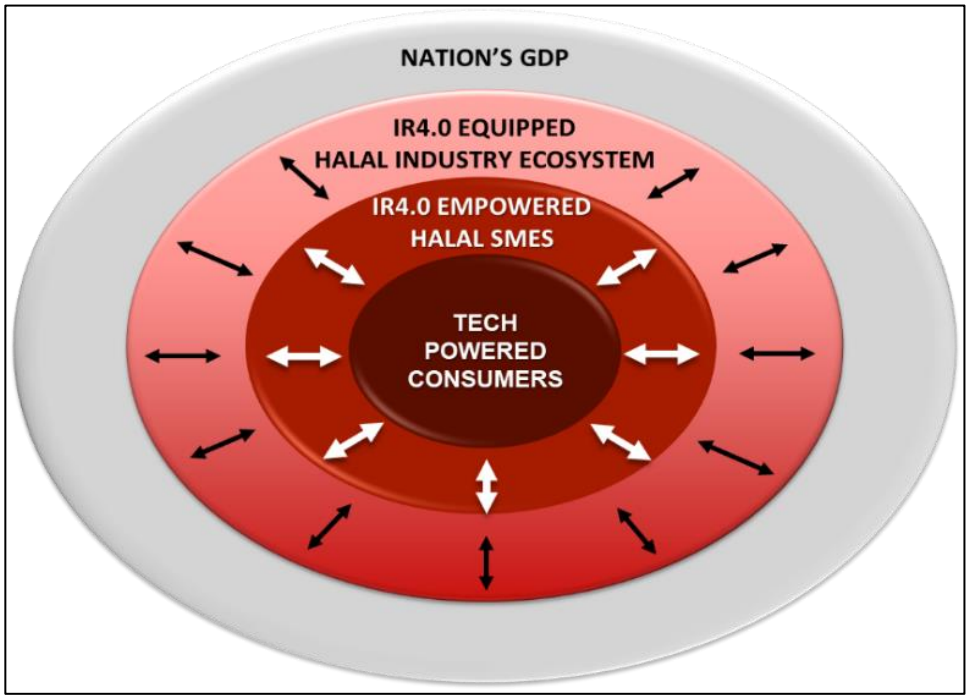

Figure 5. Proposed Framework of IME Inclusivity within Halal Ecosyste. Source: Authors' own model

Meanwhile, Figure 5 is a proposed model illustrating a dynamic ecosystem where consumers are empowered to make informed and ethical decisions through IR4.0 technologies, in accordance with the principles of IME. Within the TBL framework, organisations leverage AI, Big Data Analytics, and Blockchain to enchance operational performance, thereby attaining economic efficiency, social equity, and environmental sustainability. This synergy not only promotes organizational excellence but also establishes the Halal industry as a significant contributor to the nation's Gross Domestic Production (GDP). The transformative role of IR4.0 technologies in reinforcing consumer trust, fostering innovation, and advancing national economic objectives in alignment with IME principles is underscored by the model, which promotes transparency, inclusivity, and sustainable practices.

The Future of the Halal Industry: A Leader in Ethical and Sustainable Consumption

The implementation of IR4.0 technologies in the Halal industry holds significant disruptive potential; nevertheless, a thorough investigation uncovers both opportunities and limitations. Blockchain technology, albeit providing transparency and traceability, encounters practical application challenges. These encompass elevated expenses, the necessity for technological proficiency, and opposition from conventional stakeholders who may view digital transformation as disruptive (Rao et al., 2024; Sibiya, 2023). Moreover, although Blockchain guarantees immutability, the initial data entry remains dependent on human accuracy and integrity, hence allowing for possible errors or fraudulent activities. AI and Big Data Analytics substantially improve market responsiveness and sustainability by delivering real-time insights into customer behaviour and supply chain efficiencies. Nonetheless, issues including data privacy concerns, the ethical application of AI in decision-making, and the substantial investment expenditures for technological implementation must be resolved. Smaller Halal firms may face challenges in adopting these technologies due to limited financial and technical resources, thereby exacerbating the disparity between large and small market participants (Khan & Mirakhor, 1989).

The congruence of IME principles with IR4.0 technology offers a robust framework for attaining economic justice, sustainability, and social fairness. Operationalising this synergy necessitates extensive regulatory structures that guarantee adherence to both Halal and ethical norms. Although Blockchain can enable Shariah-compliant financial transactions, widespread use of these systems necessitates interaction with global financial infrastructures, which may not be entirely compatible with IME principles (Mohammad, 2010). AI-driven resource optimization corresponds with IME's focus on sustainability; nevertheless, the environmental advantages must be weighed against the energy-intensive characteristics of AI technology.

Considering these consequences, it is evident that the technological evolution of the Halal industry presents an opportunity for worldwide leadership in ethical and sustainable consumption. Nonetheless, it requires proactive measures to tackle challenges including financial constraints, opposition from stakeholders, and regulatory deficiencies. Future research ought to examine scalable strategies for technology adoption that encompass micro and small firms, and also assess the long-term effects of IR4.0 technologies on sustainability and ethical compliance within the Halal industry.

In conclusion, although the incorporation of IR4.0 technology enables the Halal industry to enhance IME principles and excel in ethical and sustainable practices, realising this promise necessitates overcoming substantial implementation hurdles. These initiatives require inclusive policies, stakeholder education, and continous research. By harnessing the advantages of Blockchain, Big Data, and AI while addressing their shortcomings, the Halal industry can demonstrate how conventional ethical frameworks can prosper in the contemporary technological environment, thereby advancing "The Future of the Halal Industry: A Leader in Ethical and Sustainable Consumption".

Conclusion

Finally, this paper has provided a comprehensive analysis of the significant impact that IR4.0 technologies and data-driven approaches can have on the Halal industry, driving it towards sustainability, inclusivity, and ethical integrity. Through the utilization of Blockchain, Big Data Analytics, and AI, stakeholders can optimize operations, improve efficiency, and uphold the core principles of IME. By deliberately leveraging these technologies, the Halal sector may advance financial inclusion, enhance customer satisfaction, and champion ethical procurement methods that align with Islamic principles.

Collaborative efforts among businesses, regulators, financial institutions, and consumers are essential for achieving a more inclusive and sustainable Halal industry. Recognizing the importance of embracing innovation and technology-driven solutions, it becomes clear that addressing the industry's complex challenges is crucial. These challenges range from ensuring transparency and traceability in the supply chain to promoting fair access to financial resources for marginalised communities. Furthermore, through the incorporation of IME principles into business practices and decision-making processes, the Halal industry has the potential to become a role model for ethical and sustainable economic development.

It is crucial for the Halal industry to embrace innovation and adapt to the changing global commerce landscape. By remaining at the cutting edge of technological advancements and placing a strong emphasis on ethical considerations, the industry can fully harness its potential as a catalyst for economic growth, social equality, and environmental sustainability. This paper provides a comprehensive analysis of the potential benefits of IR4.0 for the Halal industry and the communities it serves. It emphasises the need for stakeholders to take action and capitalize on these opportunities to create a more prosperous and inclusive future.

References

Abdelrahman, R., Karim, R., & Kevin, D. (2021). Halal food supply chains: A literature review of sustainable measures and future research directions. *Foods and Raw materials*, *9*(1), 106-116.

Abdullah, S., & Oseni, U. A. (2017). Towards a Shari'ah Compliant Equity-based crowdfunding for the halal industry in Malaysia. *International Journal of Business and Society*, *18*(1), 223-240.

Ali, S., & Rizwan, M. (2023). Understanding halal consumers' preferences: A systematic review and future research directions. *Journal of Islamic Marketing*, *14*(1), 182-207.

Al-garadi, M. A., Fayad, M. E., & Khalil, M. I. (2020). Big data analytics in the halal food supply chain: A conceptual framework for real-time monitoring and decision-making. *Sustainability*, *12*(14), 5674.

Azam, M. S. E., & Abdullah, M. A. (2020). Global halal industry: realities and opportunities. *International Journal of Islamic Business Ethics*, *5*(1), 47-59.

Bakar, N. A., & Rosbi, S. (2019). Robust framework of Halal certification process with integration of artificial intelligent method. *Journal of Islamic, Social, Economics and Development* (JISED), *4*(20), 47-55.

Barbosa, M. W., Vicente, A. D. L. C., Ladeira, M. B., & Oliveira, M. P. V. D. (2018). Managing supply chain resources with Big Data Analytics: a systematic review. *International Journal of Logistics Research and Applications*, *21*(3), 177-200.

Billah, A., Rahman, M. A., & Hossain, M. T. B. (2020). Factors influencing Muslim and non-Muslim consumers' consumption behavior: A case study on halal food. *Journal of Food Service Business Research*, *23*(4), 324-349.

Chaudhry, S. (2022). Environmental stewardship: Perspectives from the Islamic teachings. African *Journal of Public Administration and Environmental Studies (AJOPAES)*, *1*(1), 121.

Chukwu, E., Adu-Baah, A., Niaz, M., Nwagwu, U., & Chukwu, M. U. (2023). Navigating ethical supply chains: the intersection of diplomatic management and theological ethics. *International Journal of Multidisciplinary Sciences and Arts*, *2*(1), 127-139.

Evans, S., Vladimirova, D., Holgado, M., Van Fossen, K., Yang, M., Silva, E. A., & Barlow, C. Y. (2017). Business Model Innovation for Sustainability: Towards a Unified Perspective for Creation of Sustainable Business Models. *Bus. Strat. Env.*, *26*, 597–608. https://doi.org/10.1002/bse.1939

Foenna, A., Kamal, S., & Ating, R. (2020). The impact of industrial revolution 4.0 and its manifestation in Islamic finance industry. *International Journal of Accounting, Finance and Business*, *5*(26), 70-90.

Gusenbauer, M. (2019). Google scholar to overshadow them all? Comparing the sizes of 12 academic search engines and bibliographic databases. *Scientometrics*, *118*(1), pp. 177-214.

Hassan, M. K., Shah, M. A. R., Alazhari, M. A., & Selim, M. (2021). Towards the implementation of monetary management in Islamic economic system based on recent developments. *International Journal of Islamic Economics and Finance (IJIEF)*, *4*(2), 177-206.

Hassan, M. K., Rabbani, M. R., & Chebab, D. (2021). Integrating Islamic finance and halal industry: Current landscape and future forward. *International Journal of Islamic Marketing and Branding*, 6(1), 60-78.

Hendayani, R., & Fernando, Y. (2023). Adoption of blockchain technology to improve halal supply chain performance and competitiveness. *Journal of Islamic Marketing, 14*(9), 2343-2360.

Hotman, H. (2024). Islamic Economics and Sustainable Development Goals (SDGs): Bridging the gap through ethical financial practices. *Economics Studies and Banking Journal (DEMAND), 1*(2), 53-60.

Ibrahim, M. H., & Alam, N. (2018). Islamic economics and Islamic finance in the world economy. *The World Economy, 41*(3), 668-673.

Iswanto, B. (2023). Job creation law and consequences in determining halâl products: Analysis of the Halâl Product Fatwa Committee. *AL- ADALAH*, *20*(1), 179–179. https://doi.org/10.24042/adalah.v20i1.16379

Iqbal, Z., & Mirakhor, A. (2017). *Ethical dimensions of Islamic finance: Theory and practice.* Springer.

Iskandar, A. & Saputra, J. (2023). The role of the digital economy in the development of the halal industry and the Shari'a economy in Indonesia: SWOT analysis. *Jurnal Indo-Islamika, 13*(1), 34-49. https://doi.org/10.15408/jii.v13i1.32029

Kader, H. (2021). Human well-being, morality and the economy: an Islamic perspective. *Islamic Economic Studies, 28*(2), 102-123.

Khan, M. S., & Mirakhor, A. (1989). The financial system and monetary policy in an Islamic economy. *Journal of King Abdulaziz University: Islamic Economics, 1*(1), 39-57.

Halevi, G., Moed, H. and Bar-Illan, J. (2017). Suitability of google scholar as a source of scientific information and as a source of data for scientific evaluation, *Revi Lit*, *11*(3), 823-834

Hamidi, M. L., & Worthington, A. C. (2023). Beyond the triple bottom line: Prosperity, people, planet, and prophet in Islamic banking. Journal of Islamic Marketing, *14*(2), 394-409.

Masood, A., Hijrah Hati, S. R., & Abdul Rahim, A. (2023). Halal cosmetics industry for sustainable development: A systematic literature review. *International Journal of Business and Society*, *24*(1), 141–163. https://doi.org/10.33736/ijbs.5609.2023

Mahamud, A. O. (2019). *Sukuk as a tool towards development: How kenya can use sukuk as alternative source of funding development projects*. (Doctoral dissertation). University of Nairobi.

Mohammad, M. T. S. H. (2010). Principles of sustainable development in Ibn Khaldun's economic thought. *Malaysian Journal of Real Estate, 5*(1), 1-18.

Mustafid, F., Nasution, K., & Sodiqin, A. (2024). Positivization of the council of Indonesian ulema's halal fatwa: Policy and position in Indonesian legislation. *JURIS (Jurnal Ilmiah Syariah), 23*(1), 156-166. https://doi.org/10.31958/juris.v23i1

Novianti, D., Arkeman, Y., Almunawar, M. N., Haditjaroko, L., & Ismayana, A. (2020). Designing a transparent distributed systems for halal supply chains using blockchain technology. *Journal of Business and Economic Analysis, 3*(02), 151-170.

Prashar, D., Jha, N., Jha, S., Lee, Y., & Joshi, G. P. (2020). Blockchain-based traceability and visibility for agricultural products: A decentralized way of ensuring food safety in India. *Sustainability, 12*(8), 3497.

PRRI. (2023). "*Religion population by country*". Pew Research Center. https://www.pewresearch.org/religion/2022/12/21/key-findings-from-the-global-religious-futures-project/

Qotadah, H. A., Al-anshory, A. C., Achmad, A. D., & Syarifah, M. (2022). Cultured meat for Indonesian Muslim communities: A review of maslahah and prospect. *Al-Istinbath: Jurnal Hukum Islam, 7*(2), 329-346. https://doi.org/10.29240/jhi.v7i2.5476

Rao, K. S., Lean, C. P., Ng, P. K., Kong, F. Y., Khan, M. R. B., Ismail, D., & Li, C. (2024). AI and ML in IR4. 0: A short review of applications and challenges. *Malaysian Journal of Science and Advanced Technology, 4*(2), 141-148.

Rejeb, A., Rejeb, K., & Keogh, J. G. (2021). Enablers of augmented reality in the food supply chain: a systematic literature review. *Journal of Foodservice Business Research, 24*(4), 415-444.

Samad, T. F. D. (2019). Distribution in Islamic economic perspective (critics to capitalist). *Tasharruf: Journal Economics and Business of Islam, 4*(2), 156-169.

Saratian, E., Arief, H., Ramli, Y., Permana, D., & Soelton, M. (2022). Sharia financial inclusion as the catalyst for the sustainability of the indonesian msmes. *ICCD*, *4*(1), 237-243. https://doi.org/10.33068/iccd.v4i1.471

Shaffril, H. A. M., Samsuddin, S. F., & Abu Samah, A. (2021). The ABC of Systematic Literature review: the Basic Methodological Guidance for Beginners. *Quality & Quantity*, *55*(1), 1319–1346. https://doi.org/10.1007/s11135-020-01059-6

Shaffril, H. A. M., Samah, A. A., & Samsuddin, S. F. (2021b). Guidelines for developing a systematic literature review for studies related to climate change adaptation. *Environmental Science and Pollution Research*, *28*(18), 22265-22277.

Sharma, S., Gahlawat, V. K., Rahul, K., Mor, R. S., & Malik, M. (2021). Sustainable innovations in the food industry through artificial intelligence and big data analytics. *Logistics*, 5(4), 66.

Sibiya, B. (2023). *Digital transformation of cities through emerging Industry 4.0 smart technologies and infrastructure in South Africa.* (Doctoral dissertation). University of Johannesburg.

Wan, J., Li, X., Dai, H. N., Kusiak, A., Martinez-Garcia, M., & Li, D. (2020). Artificial-intelligence-driven customized manufacturing factory: Key technologies, applications, and challenges. *Proceedings of the IEEE*, *109*(4), 377-398.

World Halal Council. (2024). *"The halal market"*. https://www.worldhalalcouncil.com/

Worldometer. (2024). "*World population clock"*. Worldometers. https://www.worldometers.info/world-population/

Yakar, E. E. (2021). *Islamic law and society: The practice of iftā'and religious institutions.* Routledge.

Yaqub, M. Z., & Alsabban, A. (2023). Industry-4.0-Enabled digital transformation: Prospects, instruments, challenges, and implications for business strategies. *Sustainability*, *15*(11), 8553.

Zaidi, M. F. A. (2020). Propositions on the relationships between technology complexity, industry 4.0, and halal sustainability. *Journal of Engineering and Science Research*, *4*(1), 52-58.

Zarrouk, J. (2015). The role of Islamic finance in achieving sustainable development. *Development Finance Agenda (DEFA)*, *1*(3), 4-5.