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Securing Halal Integrity Resilience of Halal Meat Ecosystem for Society 5.0 Needs through IR4.0 Technologies

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Abstract

Malaysia maintains its leading position in Islamic finance, halal food, Muslim-friendly tourism, media, recreation, pharmaceuticals, and cosmetics for a decade, showcasing its commitment to the halal industry. The global halal meat market, driven by a significant portion of the population, is projected to reach USD 375.05 billion by 2030, with a 7.1% annual growth rate. Halal is viewed as a new standard for achieving various Sustainable Development Goals (SDGs), including health, economic growth, responsible consumption, and environmental sustainability. To stay competitive, halal supply chains must embrace advanced Industrial Revolution 4.0 (IR4.0) technologies like the Internet of Everything (IoE) for future readiness. IoE enhances connectivity, intelligence, and decision-making, empowering halal stakeholders to navigate present and future challenges and serve Society 5.0 while ensuring the sustainability of their enterprises in alignment with Maqasid al-Syariah.

Keywords: *Halal Meat Industry, Halal Integrity, Society 5.0, IR4.0 technology, Maqasid al-Syariah*

INTRODUCTION

The flourishing Halal sector has sustained its exponential expansion in tandem with the Muslim ummah, an estimated 31% of the world's population with a membership of 2.2 billion in 2023 and 3 billion by 2060 (Bhutto et al., 2022; Islamic Services of America, 2023). Notwithstanding the severe health and economic upheaval engendered by the COVID-19 pandemic, the State of the Global Islamic Economy Report 2022 (SGIER 2022) disclosed that ethical consumption requirements rooted in the Islamic faith will influence the expenditure of $2.29 trillion worldwide in 2022 across the food, pharmaceutical, cosmetics, fashion, travel, and media/recreation industries, which collectively provide services and products fundamental to the Islamic faith. This amount signifies a yearly increase of 9.5% in Muslim expenditures, commencing at $2 trillion in 2021. According to Straits Research (2022), the halal meat market is anticipated to attain a valuation of $375.05 billion by the year 2030. While this represents the core Islamic economy market, its appeal continues to grow as non-Muslim consumers align with the underlying ethical economy values. These non-Muslims, who practise responsible consumerism, believe that Halal can help them achieve the following SDGs: SDG 3 (good health and well-being), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption).

While the definition of *halal-toyyiban* matches SDG 3 goals, Halal management and production processes encompass SDG 13 and SDG 14, which are to protect the environment and all living things on Earth. The Halal economy facilitates long-term social welfare through environmental improvements, inclusive economic development, economic security, and increased and improved employment opportunities, owing to the all-encompassing character of the Halal business. This attribute aligns with SDG 8, which advocates for balanced and inclusive economic expansion, adequate and productive labour, and equitable employment for all. On the contrary, the *halalan-toyyiban* ideology advocates for conscientious production practices that tackle the SDG 12 objectives and endorse positive, pristine, and wholesome elements in consumption. Figure 1 encapsulates the similarity of values with SDGs values and production), SDG 13 (life below water) and SDG 14 (life on land).

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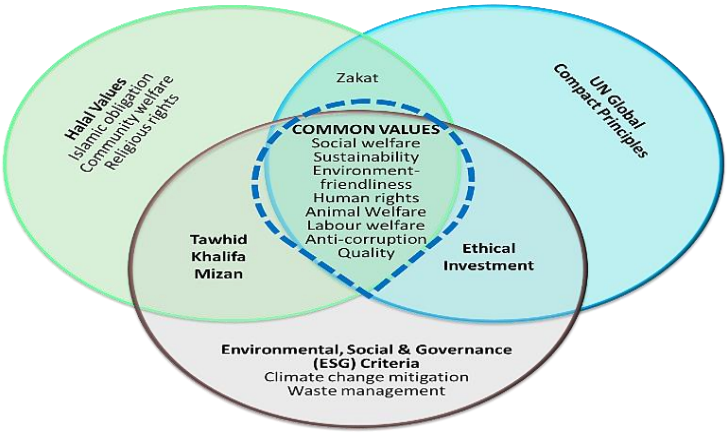
Figure 1: Global Halal Ecosystem common values are aligned with SDGs and ESG criteria.



Source: Halal Development Corporation "Halal Ecosystem Concept and Indicators" 2021 (HDC website)

To Muslims, Islam is a way of life with values that have universal appeal that touches many sectors. The concept of Halal is comprehensive and transcends beyond the ingredients, to comprise the source of raw materials, entire production process, supply chain, and logistics. Global Halal ecosystem covers beyond the basics of rituals and focuses on safety and development. However, the misconception that Halal products refer to pork and alcohol-free products amongst the global population is common and still persists until now. In reality, Halal denotes "permissible" or "lawful", whereas Haram means anything "prohibited" and "unlawful" (Widyanto & Sitohang, 2022; Masood, 2021). Despite being one of the most competitive and fast-moving industries in the world, the Halal industry is significantly reliant on an uninterrupted Halal supply chain, is plagued by Halal integrity difficulties, and lacks a globally agreed Halal standard. Numerous businesses and other Halal stakeholders are leveraging their governments' Halal initiatives to become more viable in this challenging economic situation. Many are also investing in Halal development by embracing modernisation and expanding solutions for the world's Muslim societies (Fadzillah, 2022).

Globalisation has continuously escalated interdependence and mutuality among and between countries, and subsequently changed our daily lives (Kim & McLean, 2015). The internationalization of supply chains indicates that diverse cultures, differing climates, and assorted infrastructures would have affected the Halal production (Simangunsong et al., 2016). The lockdowns imposed by COVID-19 pandemic disrupted the global supply chain and adversely affected supplies. This situation has hampered small and medium enterprises (SMEs) efforts to survive, remain sustainable, and expand beyond their country's border (UNCTAD, 2022). The post-COVID period is far more difficult than anticipated. Supply chain disruptions caused by protracted geopolitical tensions, the energy crisis, inflationary pressures, commodity price volatility, and dramatic weather variations are projected to produce more turbulence in global trade, with SMEs frequently at the forefront. The prolonged conflict between Russia and Ukraine has had a significant influence on the global supply chain, threatening food security in even huge economies such as the United Kingdom (The Straits Times, 2022).

As per Rajah and Woeffray's findings in 2022, approximately 90% of businesses worldwide consist of small and medium-sized enterprises (SMEs). These enterprises play a significant role by contributing to approximately 70% of global employment and gross domestic product (GDP). Nevertheless, regardless of their substantial role in many countries' economies, SMEs are stumbling behind in terms of digital transformation. This situation may have emerged due to widespread apprehensions regarding sustainability and expansion. Consequently, numerous governments, including Malaysia's, have taken appropriate measures, such as the SME Digitalisation Initiative, to alleviate the situation. This encompasses enhancing the internet accessibility and digital marketing capabilities of small and medium enterprises (SMEs), along with allocating cash for the enhancement of their manufacturing equipment and machinery (MDEC website - 2024).

In the era after the pandemic, there has been a notable rise in digital transformation, accompanied by the changing demands and actions of consumers. Fadzillah (2022) emphasised the necessity of innovation in the rapidly expanding Halal sector, highlighting the significant role of technology in driving progress in the growth of the Halal industry. The integration of Industry 4.0 (IR4.0) technology has brought about substantial advancements in the modernization of the Halal industrial sector. Halal organizations are adopting sophisticated technologies such as artificial intelligence (AI), machine learning (ML), radio frequency identification (RFID) chips, blockchain, and the Internet of Things (IoT) as part of the certification process for Halal food. By leveraging advanced technologies like distributed ledger technology (DLT), blockchains, artificial intelligence (AI), and cloud computing, Halal manufacturing processes can meet the objectives of Sustainable Development Goals (SGDs) while also fulfilling environmental, social, and governance (ESG) commitments. Digital ledger technology, also known as DLT, is a system that enables the simultaneous recording of transaction details in many locations, ensuring accurate tracking of online transactions. Distributed ledgers lack a centralised data repository or administrative capability, in contrast to conventional databases. Due to the implementation of distributed ledger technology (DLT), stakeholders can more effectively evaluate the impacts of Halal production on Sustainable Development Goals (SDGs) and Environmental, Social, and Governance (ESG) factors.

This is because transactions involving these monies are now more transparent and can be easily traced. Cloud computing enhances communication efficiency and consolidates data, whilst BDA (Big Data Analytics) offers valuable insights (Mohbey & Kumar, 2022). Thanks to cutting-edge Industry 4.0 technology, Halal food product origins can be more easily traced, and the Halal market can function more openly. These efforts are particularly evident in Malaysia, Indonesia, Turkey, OIC nations, and countries that export Halal meat. Marketers have extensively employed IR4.0 technology not just for marketing endeavours, but also as a means to gather data and gain a deeper comprehension of evolving client behaviour. Participating halal businesses in Malaysia need to adapt to new circumstances, focus on growth, and use creative strategies for efficiency and effectiveness. Companies and society must invest in cutting-edge innovation and have the technical expertise to tackle the Halal ecosystem's and supply chain's complexity (Fernando & Wulansari, 2021a). Undoubtedly, now is the moment for Halal stakeholders to explore adopting leading edge IR4.0 technologies and assimilate the Internet of Everything (IoE) into the Halal ecosystem in order to prepare for a human-technology-centric society known as Society 5.0. IoE, as defined by Langley in 2021, denotes the interconnections among individuals, objects, data, and procedures, amalgamated into a shared interconnected system with the aim of enhancing experiences and facilitating more informed decision-making. The application of IoE, which provides all-around connectedness, intelligence, and cognition, depicts a system that ensures effective and efficient integration of the various components of Halal economy (Fredette et al., 2012). This interactive and seamlessly connected system make IoE perfect to secure Halal ecosystem integrity as it addresses numerous issues that was previously thought to be unmanageable if taken on a global context.

As illustrated in Figure 3, there are several challenges with the Halal ecosystem due to the large number of entities participating. If the global halal ecosystem may help achieve SDG targets, how can a conducive climate be developed to promote effective, efficient, and timely decision making to ensure its sustainability and integrity?

In order to accomplish the stated objectives and resolve the problem, a literature-based approach will be implemented. This research contributes to the body of knowledge, addresses a gap in the literature, and illuminates the Halal industry. As a mediator of crises and disasters, IoE will facilitate the expansion and operation of the Halal industry. Therefore, this investigation serves as an initial survey of the scholarly literature concerning the viability of utilising IoE to fortify the Halal meat ecosystem in order to preserve Halal integrity and accomplish Maqasid Syariah and SDG objectives. It addresses compliance with standardised Halal standards, certification recognition, Halal production conformance, supply chain disruption, integrity, and traceability. By being fully integrated into the Halal ecosystem, IoE has the potential to resolve the challenges faced by the industry and gain international and Muslim acceptance.

Research Methodology

Methodology

The fundamental objective of this study is to critically examine the viability of implementing Internet of Everything (IoE) technology in order to ensure the security and integrity of the Halal meat ecosystem. By doing so, it is anticipated that this endeavour will contribute to the fulfilment of the Society 5.0 requirements, as well as the Maqasid Syariah principles and Sustainable Development Goals (SDGs) objectives. By leveraging the advancements of the Fourth Industrial Revolution (IR4.0) and embracing the Internet of Everything (IoE) framework, one can effectively enhance the level of transparency pertaining to the production process and logistical operations involved in the halal meat industry. This approach ensures that the integrity of halal practices is upheld, while simultaneously adhering to global regulations governing halal standards. Ultimately, should the successful execution of said implementation come to fruition, the Internet of Everything (IoE) possesses the potential to engender a sense of trust and fidelity within the customer base, thereby fortifying the longevity of the halal meat industry and facilitating the seamless conduct of halal trade across international borders.

The commencement of the study shall be marked by a comprehensive examination of existing scholarly works, commonly referred to as a literature review. This endeavour aims to acquire a profound comprehension of the Halal meat sector, specifically focusing on the intricate dynamics of stakeholder communication and information dissemination within its ecosystem. Furthermore, it shall evaluate the system's state of readiness and contemplate the incorporation of an Internet of Everything (IoE) framework. In order to elucidate the historical inquiry into the ecosystem of the halal meat industry and the utilisation of the Internet of Everything (IoE) within said industry, an extensive exploration of bibliographic databases and reputable business websites shall be undertaken.

The forthcoming investigation will delve into the discovered observations and propose strategies for governments, producers, and proprietors to effectively attain, sustain, and cultivate their customer base, while also identifying potential avenues for future scholarly inquiry.

Literature Review

The similarity between SDG12, which aims to build sustainable consumption and production methods, and the ideology of *halalan-toyyiban*, which promotes the inclusion of excellent, pure, and wholesome materials in consumption while advocating for responsible production processes, is evident. Likewise, SDG8 aims to foster continuous, inclusive, and sustainable economic growth, full and productive employment, and decent work for all, according to the United Nations Sustainable Development Goals. The continuous growth of the Halal economy has the potential to alleviate income distribution disparities across different segments of society. Consequently, this could lead to a more comprehensive form of development that encompasses all individuals, thereby attaining the objectives outlined in Sustainable Development Goals 8 and 12. The application of IR4.0 technologies, specifically the Internet of Everything (IoE), offers alternative approaches to tackle the enduring challenges surrounding Halal matters. By embracing these advancements, stakeholders within the Halal industry can safeguard themselves against disruptive global crises, ensuring the longevity and growth of the Halal economy.

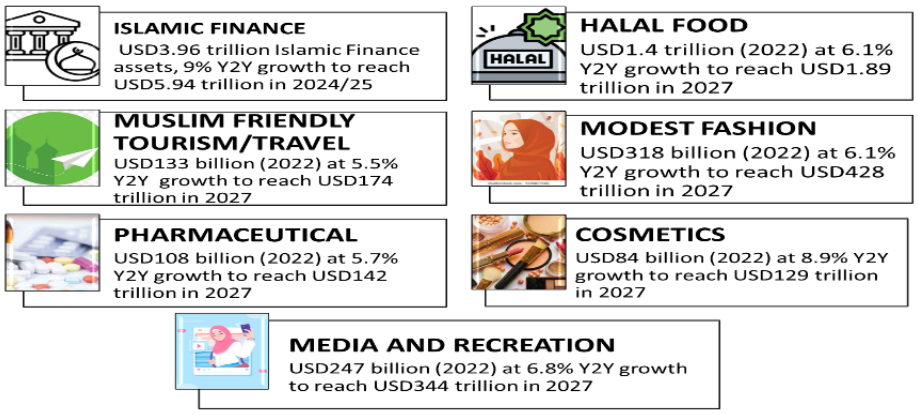
Halal Economy and Ecosystem

The high demand for Halal products and services is reflected in the most substantial expansion in over a decade for Halal sales, with Muslim expenditure anticipated to achieve a 7.5% Compound Annual Growth Rate (CAGR), reaching US$2.8 trillion by 2025, as reported by GIER in 2022. Malaysia maintains its leading position on the Global Islamic Economy Indicator (GIEI) for the tenth consecutive year, with Saudi Arabia, the UAE, and Indonesia following suit (GIER 2023). This growth is attributed to factors such as an expanding Muslim population, an increasing commitment to Islamic ethical values, widespread digital connectivity, a growing

number of national strategies dedicated to Halal product and service development, and businesses facing pressure to sustain growth, including the emergence of non-Muslim nations and consumers, all contributing to the continual expansion of the global Islamic economy. Figure 2 demonstrates the reach of Halal industry that covers various business sectors whereby there are increases in revenues of each sector increasing between 2022 to 2027.

Chong et al. (2021) documented a positive shift in the way Muslims and non-Muslims see Halal food products, particularly in connection to the *halalan-toyyiban* concepts. Ishak et al. (2016) and Nurhazirah et al. (2020) both concluded that consumers' trust in halal products is based on having full certainty about the source of their ingredients and the techniques employed in their production. Notwithstanding the disruptive repercussions of the COVID-19 pandemic, the Islamic economy has experienced consistent development. This growth can be attributed to the increased adoption of digital transformation and a stronger government focus on projects connected to food security.

Figure 2: Global Islamic Economy

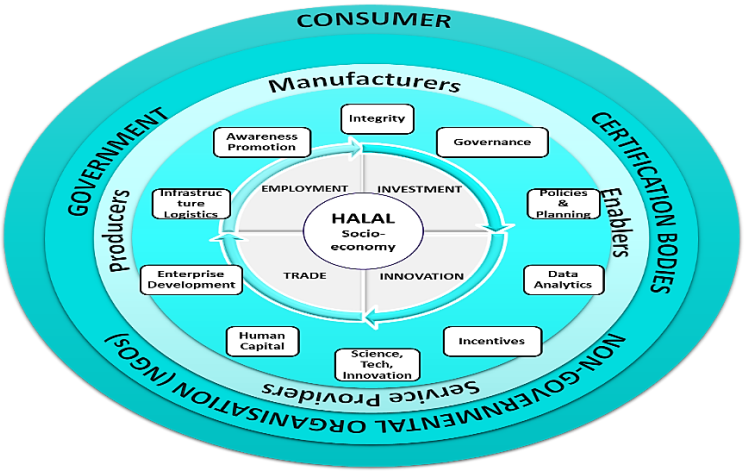


Source: Adapted from GIER 2022

The Halal Ecosystem is defined as "*A network of components involved in the growth cycle and delivery of Halal products or services and contributes to the overall Halal socio-economy. Each component in the ecosystem has its own unique activities that are interrelated with each other, in a constant evolving relationship towards sustainability*". Halal covers beyond the basics of rituals as it focuses on safety and development. Figure 2 depicts the Halal ecosystem that is made up of government ministries, agencies and associations, multinational conglomerates (MNCs), and SMEs from various sectors including manufacturers, suppliers, distributors, and consumers (HDC website).

The Halal Development Corporation (HDC) predicts that Malaysia's Halal exports will reach a value of US$9.6 billion by 2022. Significantly, exports in the first quarter have seen a 100% surge in comparison to the preceding year, suggesting strong possibilities for expansion. In a publication by Kaur (2023), it was emphasised by Hairol Ariffein Sahari, the CEO of HDC, that the number of small and medium enterprises (SMEs) with halal certification stands at a mere 8,000. In addition, he emphasised that just 2,000 exporters possess the requisite expertise and capability to access the very profitable worldwide Halal market, which is valued at RM13.3 trillion (US$3 trillion). The article recommends that governments proactively take measures to enhance the adoption of halal certification among SMEs. It suggests that nations facing a similar challenge should implement corrective actions if they wish to capitalize on the rapidly expanding Halal economy. The perception that the Halal application process is arduous, costly, and time-consuming is responsible for the lack of dedication among SMEs in acquiring Halal certification. This unfounded belief has led to many small and medium-sized enterprises (SMEs) manufacturing products that they say are 'halal' without obtaining proper Halal certification. This has had a negative impact on the credibility of the Halal status and has hindered the growth of the Halal market.

Figure 3: Malaysia's Halal Ecosystem



Source: Adapted from Halal Development Corporation "Halal Ecosystem Concept and Indicators" 2021 (HDC website)

Figure 3 illustrates the intricate nature of the Halal ecosystem, with each component operating independently yet seemingly interconnected. However, there is currently no unified platform for authorities, industry actors, and consumers to share information. The lack of connection leads to problems with Halal integrity and dissatisfaction among consumers.

Halal Meat Market Size and Supply Chain

According to Market.us, the Halal Meat Market size is projected to surpass around USD 723.7 Billion by 2032, and it is poised to reach a registered CAGR of 9.7% from 2023 to 2032.

Figure 4: Global Halal Meat Market from 2022 - 2032
Source: https://market.us/report/halal-meat-market/

The meat and alternatives sector held the largest market share of 51.6% in 2021 and is anticipated to continue to do so throughout this period. Currently, the worldwide Muslim population exceeds 2.01 billion, with the largest concentration found in Asia-Pacific and the Middle East. While not every follower of Islam strictly adheres to dietary norms, a significant majority, particularly in Muslim-majority countries, observes guidelines influenced by their interpretation of the Quran. Furthermore, individuals from diverse religious backgrounds are now embracing Islamic laws as a lifestyle, contribute to the adoption of these dietary practices. According

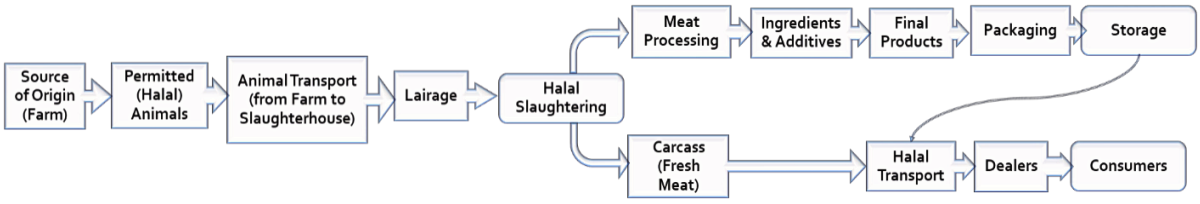
to a 2020 National Library of Medicine article, 70% of English consumers favour halal meat over conventional cattle. According to an analysis by GlobeNewswire, the demand for Halal meat is being driven by several factors. These include the expanding Muslim population, the growing preference for high-quality Halal meat among non-Muslims, increased consumption, and the expansion of Muslim-friendly tourism sectors. Asia Pacific accounted for the largest portion of the market in 2022, with a revenue share of 38.9%, primarily because to the rapid expansion of the Muslim population in the area. The Middle East and Africa have emerged as the most lucrative region in the worldwide halal meat business. This was driven by a steadfast commitment to adhering to Islamic dietary principles in countries such as Saudi Arabia, the UAE, South Africa, and others, as reported by Globe Newswire.

For their own necessities, a number of Muslim countries are compelled to purchase goods from non-Muslim nations. Although Malaysia's meat sector has charted major expansion with beef exports rising exponentially to RM21.3 million in just two years by 2022 (Hisham, 2023), Trend Economy reported that there is still heavy reliance of other meat imports from Australia (US$214 million), New Zealand (US$73 million US$) and India (US$2.5 million). All of the countries are non-Muslim countries. This same trend is also prevalent in other Muslim majority countries such as Middle East and African nations.

The expansion of the Halal Meat industry is shaped by several factors, with one key driver being the demand for convenience and value-added products driven by busy lifestyles. Included in this vogue are convenience foods and specialty items like organic and free-range Halal options. Customers place a premium on Halal products that adhere to strict quality and safety requirements, are produced organically, and are in line with humane conditions; these factors also play a significant role in their decision-making process. However, there are logistical obstacles that the sector faces, and one of the biggest ones is making sure that Halal meat products stay fresh and high-quality throughout transit and distribution. This challenge is notably pronounced in international exports, where the complexities of maintaining product integrity throughout the supply chain pose additional barriers. Unfortunately, instances of fraud continue to erode public confidence in Halal cuisine. Misuse of the Halal logo, falsification of Halal certificates and labels, mislabelling of products as Halal, employment of perplexing ingredient codes, and incorporation of non-Halal components into Halal products are all examples of issues with halal integrity.

Supply chain management (SCM) and high supply chain resilience (SCR) are essential for a business to remain competitive, adapt to a swiftly changing market, and maintain the integrity of Halal products. Figure 5 illustrates a *halalan-toyyiban* meat supply chain that necessitates the participation of both internal and external stakeholders. Evidently, any link in the hubs of the supply chain for halal meat and products is susceptible to cross-contamination and disruption. The illustration does not include the process of importing halal meat and logistics activities upon arrival at port up till retailer/wholesaler and sale to consumer where more fraudulent activities can occur.

Figure 5: Simple structure of the Halal and Tayyib meat supply chain



Source: Adapted from Aghwan and Regenstein (2019)

Halal Practice: Integrity, Concept, and Practice

The veracity of halal products, specifically in the realm of food, is a substantial apprehension for countless Muslims around. This issue has garnered significant attention among Muslim consumers, as the pursuit of halal choices is considered a religious duty. The rising apprehension among Muslim consumers stems from the

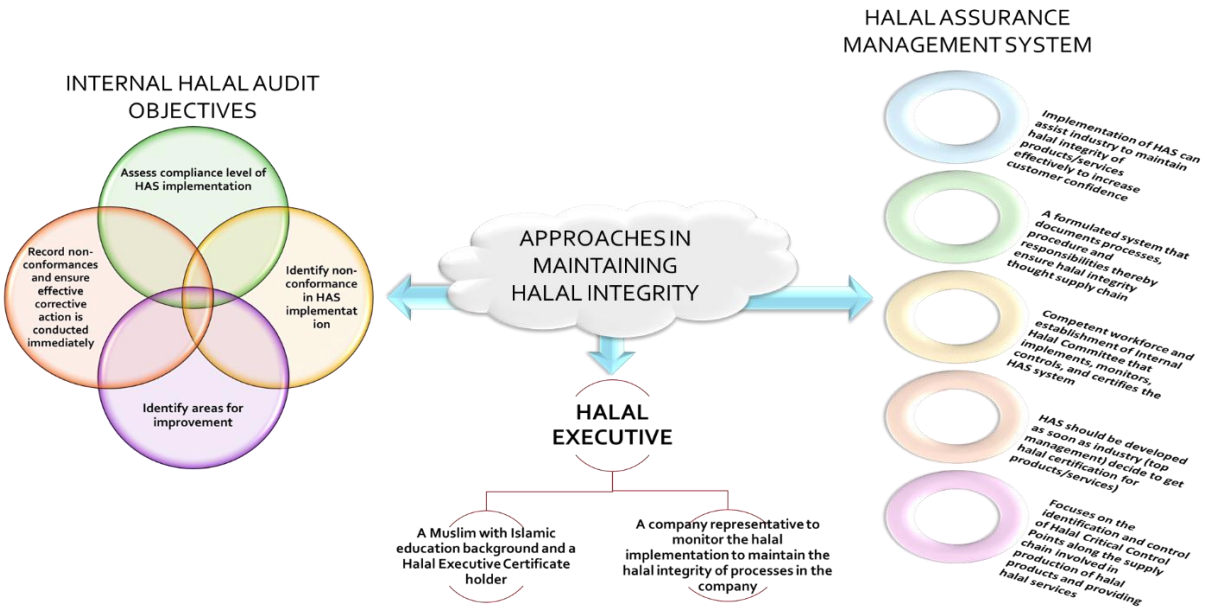
presence of counterfeit halal labels, the presence of porcine-contaminated chemicals, and uncertainties regarding adherence to traditional Islamic slaughtering criteria. Hence, it is crucial to maintain the authenticity of halal products since the integrity of halal products serves as a fundamental pillar for the prosperity of the halal business. Integrity necessitates conscientious behaviour by consistently choosing the correct course of action and executing it appropriately. Kamisah et al. (2018) define halal integrity as the practice of ensuring that all personnel, processes, and resources involved in maintaining the authenticity of halal products adhere to Shariah principles throughout the whole supply chain. This approach necessitates confidence from both customers and providers.

In addition, the concept of halal integrity can be defined as a methodical and ongoing commitment to upholding halal standards, which has an impact on both individuals and supply chain partners, ultimately enhancing corporate performance (Kamisah, 2016). In Malaysia, ensuring the genuineness of halal products has become a primary concern for both the government and customers (Tieman, 2013; Supian & Abdullah, 2019). The halal authenticity of halal food is being rigorously scrutinised at each step of the 'farm-to-fork' supply chain. The matter of integrity in the implementation of halal practices is unquestionably crucial in shaping the market appeal of halal products in countries with a significant Muslim consumer population. The advancement of technology and the highly competitive worldwide market have significantly increased customers' demand for food quality, safety, and authenticity, particularly for everyday use. Consumers' rising expectations and concerns about the quality, safety, and authenticity of halal food have prompted many enterprises to enhance their products by following halal regulations, which primarily emphasise the concept and practice of halal integrity.

It is essential to maintain the authenticity of the halal meat system, which involves adhering to Islamic dietary regulations concerning the origins of food and drinks, animal slaughter, and the absence of alcohol. This also applies to procedures and protocols associated with hygiene, dependability, security, and quality control (Amer, 2024). Compliance with the seven stipulations specified in Section 28 of the Trade Descriptions Act (Definition of Halal) 2011 is required for a food product to be considered halal in Malaysia (Rahman et al., 2018). Presently, the main focus in the meat business is centred on ensuring the genuineness of halal certification. There have been multiple documented instances worldwide when *haram* or *mushbooh* components have been fraudulently added to meat manufacturing (Ariffin et al., 2023). Moreover, the growing number of non-Muslims involved in the halal industry raises concerns regarding the authenticity of halal cuisine. The absence of confidence in the halal emblem has led consumers, especially those who follow the Islamic faith, to actively pursue further reassurance.

This circumstance has led to an unfavourable perception and severely tarnished the reputation of halal beef in the market. Therefore, it is essential to protect the authenticity of halal meat products and avoid the incorporation of forbidden ingredients inside the halal system. Preserving and improving the integrity of halal practices within the halal meat industry is crucial for upholding Malaysia's reputation as a certified global hub for halal products, as well as for ensuring the integrity of halal and wholesome practices. In order to accomplish this objective, it is imperative that all individuals contribute to the maintenance of the halal environment, with a particular emphasis on fulfilling social obligations. Enhancing regulations for halal food is vital to promote the spiritual and physical development of customers in Malaysia (Abd Razak et al., 2020). A collaborative endeavour including all parties involved is crucial to tackle these obstacles, and it should be regarded as a joint obligation to collaboratively confront these problems. Figure 6 illustrates the necessary strategies that need to be implemented in order to guarantee the sustainability of halal integrity.

Figure 6: Maintaining the Halal Integrity



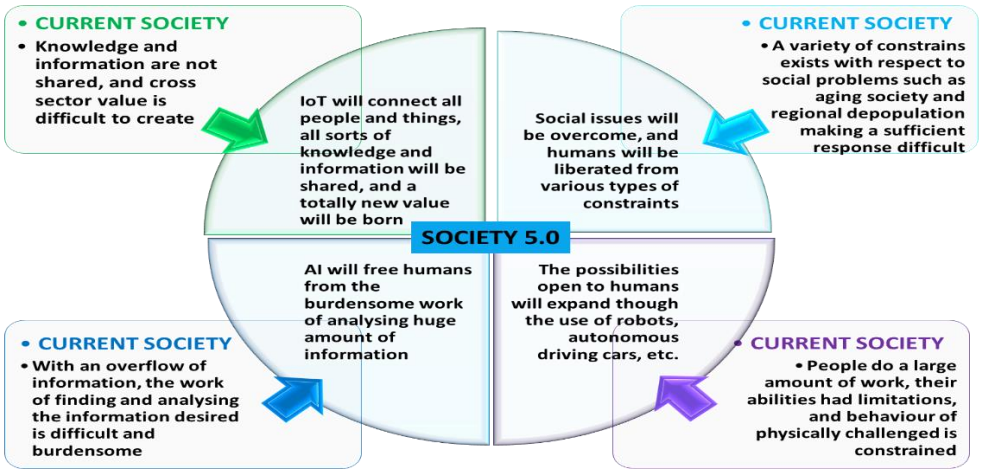
Integrating Society 5.0 Principles into the Halal Ecosystem

Society 5.0 is an advanced civilization that utilises state-of-the-art technology to create a strong link between the virtual world and the physical world. Its goal is to promote economic development and tackle the challenges of modern society. Society 5.0 is a proposed social framework that represents the evolution from hunting society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), to the information society (Society 4.0) (Government of Japan, 2015). This model and its components possess the ability to be adjusted to suit any other nation. Society 5.0 aims to integrate networked systems and persons in the digital sphere, while utilising artificial intelligence (AI) to collect and analyse information in the physical world. The results of these assessments are subsequently conveyed to humans by various means, with the goal of aiding in the preservation of a harmonious economic development, the conservation of the environment, and the resolution of growing social issues. Robots are used to assist society by doing thorough analyses, creating new values, and reducing the workload of people's daily jobs (Fernando et al., 2021b). It represents a considerable progress from the current societal framework, with the potential to greatly enhance human lives. This advancement is expected to result from the fourth industrial revolution, enabling a harmonious cohabitation between humans and machines.

Furthermore, Artificial Intelligence (AI) will extensively infiltrate diverse domains of life, including healthcare, the environment, scientific research, and ethics (Gomez et *al.*, 2020). Caryannis et al. (2021) defines Society 5.0 as a society that prioritises human needs and achieves a harmonious balance between economic and technical progress. This is accomplished through the utilisation of highly intelligent AI data systems to address societal challenges. It embodies a novel perspective for a more intelligent society in which humans, nature, and technology collaborate to establish a sustainable equilibrium bolstered by data. Society 5.0 effectively utilises the revolutionary possibilities of Industry 4.0 technologies to enhance the global environment and enhance human experiences. In the realm of cyberspace, Society 5.0 efficiently gathers and archives vast quantities of sensor data. The potential of artificial intelligence resides in its capacity to utilise the vast quantities of data generated by the Internet of Things, transforming it into a novel kind of intelligence that includes all facets of society. The objective is to enhance the human experience by offering precisely tailored products and services that prioritise both comfort and sustainability. Artificial intelligence processes extensive data in cyberspace and subsequently delivers important insights to persons in the physical domain through several routes. The effectiveness of the worldwide food distribution network is credited to knowledgeable stakeholders who possess a deep understanding of food supply trends and prevailing market circumstances (Hitachi, 2020).

Practically, Society 5.0 has generated added value inside the halal ecosystem through the utilisation of sophisticated analytical technological tools. Food businesses may effectively adapt to changing market conditions, develop new markets, and meet consumer demands for healthy and environmentally sustainable products by utilising rapidly processed data. Undoubtedly, the use of an integrated system and data will enhance quality, safety, and security in the realm of food production (Fernando et al., 2021b). The progressive advancements in technology should be regarded not solely as a final goal, but also as a highly efficient method to provide answers, facilitating the complete achievement of Society 5.0 needs. In addition, the realization of Society 5.0 is anticipated to yield substantial economic expansion, foresee a future, and concurrently alleviate the detrimental impacts on the environment, as depicted in Figure 7.

Figure 7: Society 5.0



Source: Adapted from Prakoso, GJD (2021)

The Interconnected Landscape of IoE: Beyond the Internet of Things and Impact on Society 5.0

The Internet is an extensive global network that interconnects computers worldwide, enabling the exchange and dissemination of information and communication from any location with an Internet connection. In his 1961 article "Information Flow in Large Communication Nets," Leonard Kleinrock initially introduced the concept of the Internet (Bay, 2021). In 1962, J.C.R. Licklider made a prediction that the future of computers will involve a vast interplanetary computer network that would connect individuals from all corners of the globe (Britannica). The establishment of this interplanetary computer network has become imperative, as it serves as a platform for many activities such as purchasing, conversing, socialising, teaching, learning, and entertainment.

The epidemic has taught us that digital platforms enable remote work and virtual communication, overcoming the limitations of physical presence. The Malaysian Department of Statistics reports that firms produced RM279 billion in e-commerce revenue in the third quarter of 2021, representing a 17.1 percent increase compared to the same period in the previous year. This implies that the metaverse will endure beyond the current trend of online businesses rising and falling, as stated by Murali Raman in 2022, provided that it is fully incorporated into corporate strategies and societal goals.

The digital landscape is rapidly evolving, driven by the convergence of powerful technologies like the Internet of Things (IoT) and the Internet of Everything (IoE). While IoT focuses on connecting individual devices for data collection and exchange, IoE takes a more holistic approach, encompassing not only devices but also people, data, and processes within a unified intelligent system. Understanding this intricate interplay involves delving into the core concepts.

The Power of IoT

Real-time Data Exchange: As Shafiq (2022) aptly describes, IoT facilitates the seamless exchange of data between interconnected devices without human intervention. This real-time information flow empowers remote work by providing instant access to crucial data, regardless of physical location.

Streamlined Automation: M2M (machine-to-machine) communication within the IoT ecosystem allows devices to autonomously perform tasks and make decisions, significantly reducing human effort and streamlining operations.

Enhanced Efficiency and Cost Savings: Rapid data transmission through network connections within the IoT framework translates to saved time and money. Data gathering and analysis become faster and more efficient, leading to optimized decision-making and resource allocation.

Towards a Unified IoE

IoE represents the next stage in this digital evolution, moving beyond mere device connectivity to create a truly intelligent and interconnected ecosystem. Bandara et al. (2016) identifies four key pillars of IoE:

People: Individuals become active participants in the IoE network, contributing data and interacting with connected devices and systems.

Objects: Physical objects equipped with digital capabilities and sensors gather and transmit data, becoming active information sources within the IoE.

Data: The lifeblood of IoE, data generated by people, objects, and processes fuels insights and drives intelligent decision-making.

Processes: Business processes seamlessly integrate with the IoE network, enabling automation, optimization, and real-time adjustments based on data-driven insights.

In addition to the IoT, the IoE requires advanced capabilities for sharing information. The goal is for real-time data from many and different IoE contexts, such as autonomous service agents, human actors, and simple sensors and robotic equipment, to be processed very instantly (Raj & Prakash, 2018). Intelligent devices powered by AI enable the development of innovative IoE-based applications that link objects and individuals in a multi-user, social environment (Miraz et al., 2018). IoE procedures involve the exchange of data and information in real-time between nodes via network "connections" (Langley, 2021; Miraz et al., 2018). The result is perceptive insights that are integrated in real time and function in unison (Masoud et al., 2019; Vandebroek, 2016). IoE fulfils the requirements of both society and institutions for supplementary data and significant information, surpassing the disruptions caused by IoT contexts. In the ecosystem of the Internet of Everything, the four pillars obtain new information and interfaces via cycles of knowledge creation (Nonaka & Toyama, 2015).

Impact on Society 5.0

This interconnected IoE framework holds immense potential for improved decision-making across various sectors. As Bandara et al. (2016) highlights, IoE technology empowers better decision-making through:

Enhanced Awareness: Access to relevant and real-time information from various sources within the IoE network provides a comprehensive understanding of the context and potential outcomes of decisions.

Smarter Actions: Data-driven insights gleaned from the IoE ecosystem inform more effective and targeted actions, leading to improved outcomes and greater efficiency.

Expanded Capabilities and Experiences: The interconnected nature of IoE unlocks new possibilities for collaboration, innovation, and problem-solving, ultimately enriching individual and organizational experiences.

Figure 8: Simplified Framework of IoE Interconnected Pillars

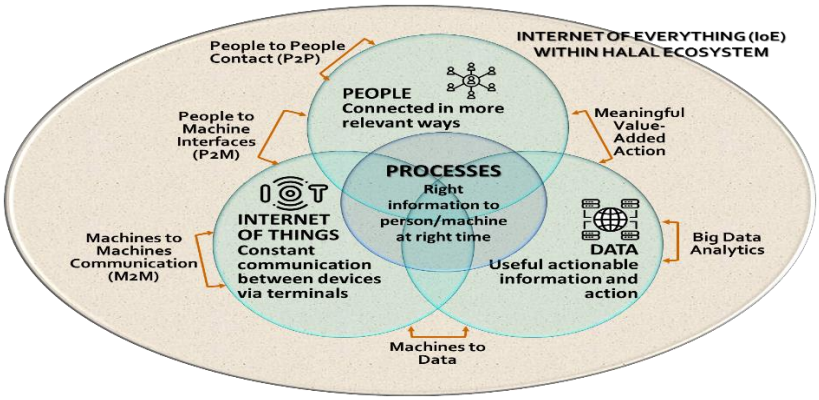


Figure 8: Simplified Framework of IoE Interconnected Pillars

body can be partially resolved by the implementation of the Internet of Everything (IoE). Authors propose a simplified model (Figure 8) to illustrate this dynamic relationship between IoE components and their impact on decision-making. As depicted, devices equipped with digital features and linked to the wider IoE network generate and exchange valuable data and information. This data is then processed in distributed hubs, enabling decentralized and agile decision-making at various levels. This decentralized approach empowers faster response times, improved adaptability, and ultimately, more effective decision-making across the organization.

Other Leading Edge IR4.0 Technologies

Stakeholders and participants in the industry must remain informed about the dynamic business ecosystem in order to increase engagement, generate revenue, and reduce expenses. The implementation of digital ecosystem transformation will facilitate this by equipping organisations with the flexibility and responsiveness necessary to confront challenges and capitalise on rational and advantageous opportunities.

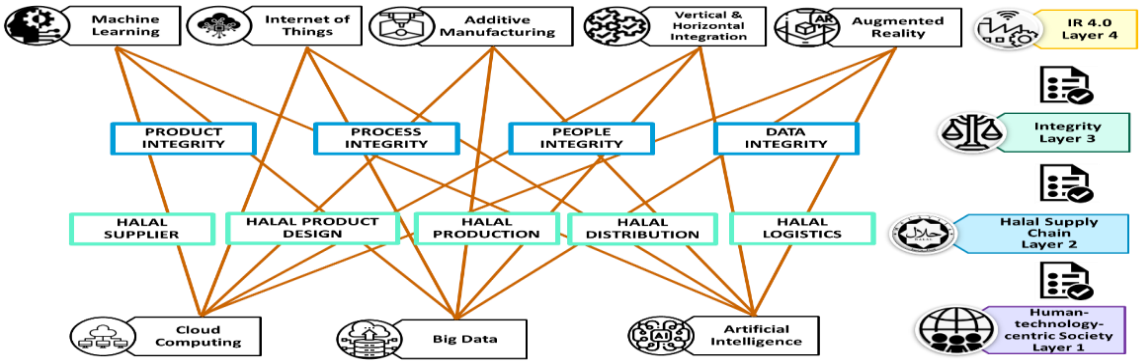
IoE technology will enhance decision-making through the provision of pertinent data, which will result in more efficient action and the expansion of capabilities and experiences. Connected to a common network of other devices, processes, and individuals, digitally enabled devices produce and exchange vital data and information, thereby accelerating the decision-making process. Numerous remote nodes process data, which facilitates decentralisation and forward-thinking decision making. IR4.0 technologies, such as fog computing, cloud computing, Artificial Intelligence (AI), machine learning (ML), the Internet of Things (IoT), Big Data (BD), and Blockchain (BC), are utilised in digital transformation.

In conclusion, the convergence of IoT, IoE and other complementary IR4.0 technologies is transforming the way we live, work, and interact with the world around us. By fostering seamless connectivity, intelligent data analysis, and decentralized decision-making, IoE holds the potential to revolutionize various industries and unlock a future of greater efficiency, agility, and informed decision-making.

Discussion

The literature study highlights that the Halal ecosystem is a dynamic and comprehensive infrastructure consisting of interconnected components with distinct associated activities. The concept of IoE integrates individuals, Internet of Things (IoT), data, and procedures into a cohesive and interconnected system. Every pillar of the Internet of Things (IoT) includes a distinct set of actions that collaborate and incorporate information into the ecosystem, with the aim of assisting customers, manufacturers, and supporting agencies in making more informed decisions. Figure 6 depicts an IoE ecosystem that is compliant with Halal requirements. The interconnected world will facilitate machine-to-machine (M2M) processes by embedding sensors in various devices or machinery, such as manufacturing lines, logistics systems, shops, and computers. Blockchain is a technology that securely stores machine-to-machine (M2M) data. This data is communicated and forwarded to a central location for processing using advanced techniques such as big data analytics and artificial intelligence (AI). Various stakeholders in the industry, including multinational corporations (MNCs), limited liability companies (LLCs), small and medium enterprises (SMEs), and micro enterprises, as well as government agencies such as JAKIM, HDCs, MOF, NPRA, MITI, and others, together with consumers and users, are provided with timely information to facilitate online decision-making using apps. The existing problems related to inconsistencies in Halal standards and transparency, diverse Halal certification practices worldwide, and the absence of a unified international Halal certifying

Figure 9: Society 5.0 Halal Supply Chain Empowered by Block Chain technology**.**



Source: Adapted from Fig. 2 Fernando et al. (2021b)

Figure 9 illustrates the significant advantages that actors in the Halal ecosystem can derive from real-time interconnection, where information is securely stored and accessible through the Internet of Everything (IoE). Industry participants will have immediate access to Halal/ Shariah compliant resources (such as information, raw materials, talent, experience, and money) and will be able to make informed decisions to tackle current and future challenges. For instance, details regarding the Halal compliance of the resources they utilise, such as the verification of Halal certification, can be readily retrieved, as can information on the Halal export regulations of the importing country. Actors within the Halal supply chain will derive advantages from receiving timely and pertinent information, enabling them to devise effective strategies and prevent disruptions in the supply chain, resulting in time and cost savings. Purchasers and end users can obtain accurate information regarding the Halal goods they aim to purchase, as they are guaranteed the product's Halal authenticity. This assurance significantly impacts consumer behaviour in a positive manner. The enhanced guarantee will enhance consumer loyalty and elevate the brand value of Halal enterprises.

Conclusion and Future Implications

The Halal industry has transitioned from being disregarded to being acknowledged as one of the most competitive, dynamic, and promising sectors globally in terms of growth potential. Halal, as a novel approach to address worldwide issues such as food safety, environmental awareness, economic viability, and animal welfare, aligns with Sustainable Development Goals 3, 8, 12, 13, and 14.

Nevertheless, the Halal industry faces challenges in maintaining the integrity of the Halal supply chain and managing logistics. These issues are compounded by the lack of a standardised Halal standard and a global certification body for Halal products. The mentioned barriers have consistently hindered the global expansion of domestic Halal industries.

Applying the Internet of Everything (IoE) to the Halal environment could potentially offer a solution. The Halal ecosystem encompasses the same components as the Internet of Everything (IoE), including things (devices/equipment/machines), people (industry players, governing agencies, consumers, end-users), processes (logistics, production, transactions, communications, marketing), and data (Halal standards, import/export requirements, suppliers, ingredients, etc.).

The worldwide epidemic and other recent disasters have shown how eager everyone is to embrace digital revolution and how quickly it is happening. This is due to the fact that, as it permits efficient communication, connectivity, and accessibility, digital transformation has grown into a necessary condition for continuing trade and transactions. To ensure a steady flow of products to customers and to remain relevant in their market, numerous organisations have decided to boost their investments in digital transformation. The cosmetics, food and beverage, and pharmaceutical industries are among those that have partially embraced the IoE. The Halal industry may follow suit if it wants to maintain its current rate of expansion. The Halal ecosystem would greatly benefit from incorporating the IoE, which would guarantee the company's long-term success, sustainability, and growth. To accomplish these objectives, however, will necessitate substantial work from a wide range of parties.

Although currently too costly for widespread commercial implementation, the next technical instrument that could be utilised is quantum communication. As per the Centre for Strategic and International Studies (CSIS), this technology utilises principles of quantum physics to enhance security and enable long-distance communications while ensuring the integrity of stored data. Quantum communication offers two distinct advantages in terms of security. Conventional digital communication use keys to encode and decode messages, similar to classical bits. Quantum key distribution (QKD) use qubits to compress and transmit encryption keys, rendering them more resistant to decryption. Furthermore, qubits exhibit a high degree of sensitivity. Any endeavour to disturb or observe qubits will result in their collapse. Consequently, in the event that a third party

intercepts or observes Quantum Key Distribution (QKD) transmissions, the intended receiver will promptly become aware of it. Quantum communications have the potential to ensure the security of transmitted data and render eavesdropping unfeasible.

Irrespective of future advancements, it is crucial to recognise that the Internet of Everything bears resemblances to previous technical breakthroughs, like the initial phases of the Internet, in its role as a facilitator. The integration of this technology in both the corporate sector and society requires a thorough evaluation of important elements, although offering various possibilities, options, and significant benefits. It is critical that we prioritise the resolution of security, privacy, cost, and infrastructure concerns in order to effectively address issues such as data theft, misinformation, and identity theft.

Conflict of Interest

Authors have no conflict of interest to declare.

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