Integrating technological innovation in the halal industry: An analysis using PRISMA

Ririn Riani[1], Ihsanul Ikhwan[2], Aam Slamet Rusydiana[3]

[1]Department of Islamic Economics, Faculty of Islamic Economics and Business Management, Tazkia Islamic University College, Bogor, Indonesia
[2]Departement of Economics, Kuliyyah of Economics and Management Science, International Islamic University of Malaysia (IIUM), Selangor, Malaysia
[3]Department of Islamic Economics and Finance, Faculty of Political Science, Sakarya University, Sakarya, Turkey

Article Info

Abstract

Purpose – This study aims to provide a comprehensive evaluation of the integration of digitalization and technological advancements in the halal industry, highlighting their implications for industry development and addressing key challenges and opportunities.

Methodology – We used the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) methodology to conduct a systematic literature review, analyzing 54 research papers published between 2014 and 2024.

Findings – This study identifies the challenges and opportunities in adopting technologies such as IoT, blockchain, and AI within the halal sector, and offers suggestions for overcoming these challenges based on the existing literature. The study finds that adopting advanced technologies is essential for the sustainable growth of the halal market and emphasizes the importance of creating explicit regulations and fostering cooperation for technological innovation.

Implications – This study has significant implications for academic researchers, policymakers, and industry practitioners by providing insights into the intersection of technology and halal industry.

Originality – The originality of this study lies in its systematic exploration of the crucial role of technology in halal market growth and sustainability. This encourages industry professionals to adopt advanced technologies to enhance product visibility and regulatory compliance.

Introduction

Halal industries, which encompass Islamic finance, modest fashion, halal food, and Muslim-friendly travel, continue to drive a global halal economy that reached US$2.29 trillion in consumer spending in 2022, experiencing a 9.5% annual growth from US$ 2 trillion in 2021. Islamic finance is at the forefront of this growth, with an estimated compound annual growth rate (CAGR) of 9%, followed by halal cosmetics at 8,9%, and other halal sectors including halal food, modest fashion, Muslim-friendly travel, and halal pharmaceuticals, which have CAGRs ranging from 5.7% to 6.1% (DinarStandard, 2023)

The Halal industry is expected to experience significant growth in the coming years driven by several key factors. Among the most important is the steady increase in the Muslim population, which is growing at an annual rate of 1.5%, compared with the 0.7% growth rate of non-Muslim populations. This demographic trend suggests a 35% increase in the global Muslim population over the next two decades. By 2043, the Muslim population is projected to reach 2.2 billion, accounting for approximately 26.4% of the global population (Abdillah et al., 2022). In addition, the state of global Islamic economy report (2023) stated that one of the strongest demand drivers of the halal industry is the growing youth Muslim population. In 2023, Muslim youth and young adults (ages 15-29) comprised 27.8% of the global youth population. By 2030, it is projected that nearly three in ten of the world's youth and young adults will become Muslim. With Gen Z and millennials being the largest spenders, the youthful demographic of the Muslim population is expected to play a crucial role in the future growth of the industry (DinarStandard, 2023).

However, this promising growth is accompanied by several challenges, including the complex and time-consuming processes of halal compliance and certification (Hasan & Pasyah, 2022), and the need for safety and traceability within the halal product supply chain, but has a high cost of investment in technology (Barth, 2011). To address these challenges, innovation is required in the development of the halal industry, especially in terms of technology integration. Technology plays a key role by offering innovative solutions that increase efficiency, transparency, and consumer trust (Harsanto et al., 2024).

The Halal industry is progressively incorporating digital systems to optimize certification procedures. Technologies such as internet of things (IoT) devices, blockchain, and artificial intelligence (AI) are being amalgamated to enhance the transparency, traceability, and authenticity of halal products (Rahman & Ahmad, 2024). Blockchain technology is considered a strategic initiative as it increases the efficiency of the halal certification process (Taratori et al., 2021), increases its transparency and traceability (Alamsyah et al., 2022), and promotes value innovation in the halal industry through its features (Carayannis et al., 2012). In addition, Tan et al., (2022) underscored the pivotal role of AI in ensuring the integrity and compliance of halal products. AI technologies contribute significantly to real-time supply chain monitoring, sophisticated data analysis, and overall enhancement of certification integrity.

The significance of technology in the development of the halal industry has resulted in an increase in discussion and literature related to this field. Figure 1 presents the development of the literature on the halal industry and its relation to technology published in the Scopus database. It was concluded that research on this topic has recently increased significantly, especially in the last ten years.
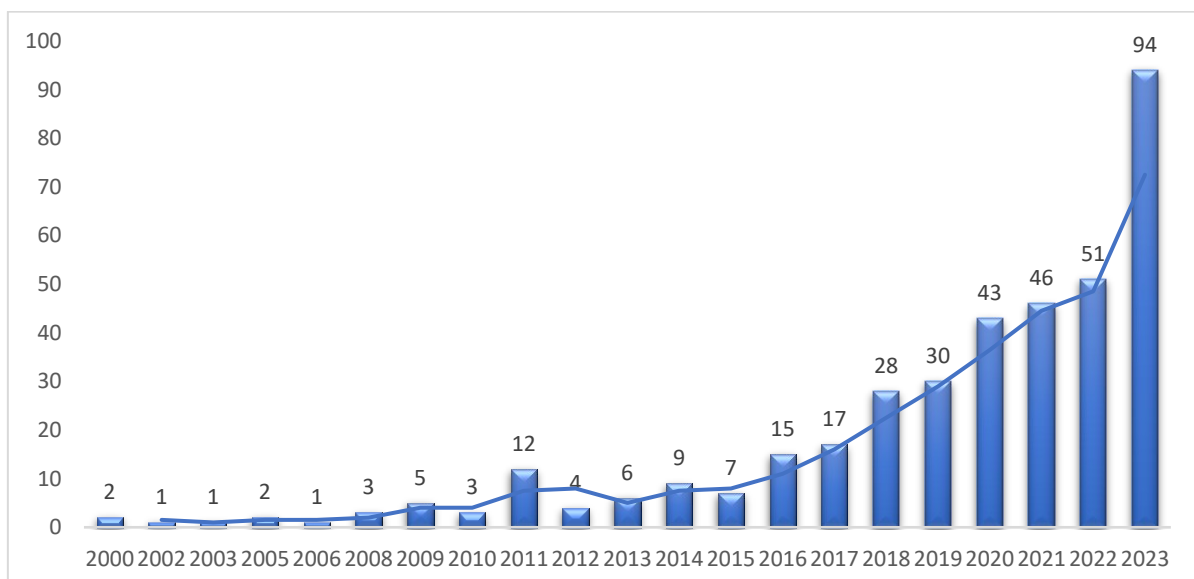

Figure 1. Development of technological innovation in the halal industry
Source: Data processed using Biblioshiny (R Studio)

Several researchers have emphasized the importance of an integrated overview that considers the specific contexts, cultures, and countries on this topic. Bridging these gaps will contribute to developing conceptual insights, forming a basis for future research on the halal industry and its relationship with technology. Therefore, a comprehensive study is needed to map the development of the literature related to the halal industry and its relationship with technological advancement.

Recent bibliometric studies in this field have been conducted by several researchers, including Noor (2024), Hastuti et al. (2023), Harsanto et al. (2024), Handayani and Vanany (2021), and Jalil et al. (2017). In contrast to existing studies, the current study attempts to conduct a comprehensive systematic literature review and eventually provide solutions for more technology-related halal industry research, which is analyzed through the preferred reporting items for systematic reviews and meta-analyses (PRISMA) method. To the best of our knowledge, there has been no research using this method concerning technological innovation in the halal industry.

Literature Review

The term "halal" means "permissible" in Arabic and refers to anything that is allowed based on *Sharia* or Islamic Law (Rahman et al., 2015). The origin of the halal industry lies in meat products, with a focus on preparing and slaughtering them following Islamic dietary regulations. Over the years, this sector has experienced a significant change, broadening its scope to include different areas like healthcare, fashion, travel, and banking. This growth is mainly due to the impact of Islamic law or ethics in these sectors and the increasing global need for halal-certified goods and services (Azam & Abdullah, 2020; Rahman & Ahmad, 2024).

A unique feature of the halal industry is its ability to overcome religious barriers. Although based on Islamic principles, the idea of halal has been acknowledged and embraced by people from various backgrounds and beliefs (Rahman & Ahmad, 2024). Halal products are frequently linked to good quality, safety, and ethical production methods, which are attractive to a wider range of consumers beyond the Muslim population.

Several factors contributed to the rapid growth of the halal industry. On the demand side, there are a large number of young Muslims, growing digital connections and online shopping in Muslim-majority countries, and the intersection of Islamic principles with sustainable and ethical consumption. On the demand side, government regulation, particularly from OIC members, was influential in requiring halal certification for imported goods, offering assistance to halal producers, and establishing regional agreements to promote trade within the OIC (DinarStandard, 2023).

This growth has been facilitated by different stakeholders such as governments, industry groups, and companies, acknowledging the economic potential of the halal market. Consequently, there has been an increase in investments, R&D initiatives, and the implementation of regulatory guidelines to maintain the authenticity of halal certifications and standards within the industry. In the digital era, the halal sector is expected to expand further, with technology playing key roles in its ongoing progress and adjustment to evolving consumer tastes and international markets (Rahman & Ahmad, 2024).

Currently, the global halal industry is experiencing a substantial shift towards digitalization. Digital tools are crucial for guaranteeing product traceability, enhancing transparency, and building consumer confidence. Furthermore, technological progress in the halal sector involves new ideas and methods to improve the quality, productivity, and legitimacy of halal goods and services. These developments utilize technologies such as blockchain, artificial intelligence (AI), big data analytics (BDA), internet of things (IoT), and biotechnology to enhance halal certification, supply chain management, product quality control, consumer engagement, and other industries.

Prior studies have highlighted the role of digital technology in improving the transparency, integrity, and certification processes of the halal industry, thereby establishing international best practices in several sectors. According to Handayani et al. (2024), the adoption of digital technology has been linked to the potential improvement in halal supply chain effectiveness, although it may impact efficiency. However, only a limited number of studies have attempted to map and comprehensively review the literature related to the integration of technology in the halal industry,

including those by Noor (2024), Hastuti et al. (2023), Harsanto et al. (2024), Handayani and Vanany (2021), and Jalil et al. (2017).

Noor (2024) did a systematic review of the literature on the technology acceptance model (TAM) application in the scope of halal industries. He found that studies in this field were first published in 2014, and Indonesia became the leading country in publishing literature on halal studies using TAM. In addition, this study found that Islamic finance was the most prominent sector in the halal industry.

Furthermore, Hastuti et al. (2023) analyzed the development of literature on halal food and its relation to technology indexed by Google Scholar using VOS Viewer. This study found that the topics often used during the observation period were food science, meat, and the food industry. This study also concludes that there is a strong interaction between food industry topics and food quality. Another study conducted a review of halal foods by Jalil et al. (2017). This study reviewed 52 articles published between 1999 and 2015 to identify studies related to technology and halal food security. The results of this study indicate that user acceptance of technology in food security is influenced by the effectiveness, convenience, and ease of use of the technology.

Handayani and Vanany (2021) conducted a systematic literature review of studies related to blockchain applications in halal supply chains published in the Scopus database from to 2017-2022. The findings indicate that manufacturing is the industry type where blockchain applications are most commonly used, while a traceability system is the primary function of blockchain applications in most of the literature. In addition, Harsanto et al. (2024) analyzed the innovative digital technology used in the context of the halal supply chain from articles published in the Scopus database. This study finds that halal financial technology, blockchain technology, and halal traceability systems are the most applied innovative technologies in the halal supply chain.

Table 1. Previous literature review studies on halal industry and technology

Author	Title	Database	Method
Noor (2024)	Technology acceptance model in halal industries: A systematic literature review and research agenda	Scopus and WoS	Systematic Literature review
Hastuti et al. (2023)	Applied technology in the halal food	Google Scholar	Bibliometric Analysis
Harsanto et al. (2024)	Digital technology 4.0 on halal supply chain: A systematic review	Scopus	Systematic Literature review
Handayani and Vanany (2021)	Blockchain application in halal supply chain: Litrature review and future research	Scopus	Systematic Literature review
Jalil et al. (2017)	Studies on technology and halal food security: A review	UM Online Library database	Kitchenham's Systematic literature review

Source: Author processed

However, prior bibliometric studies have focused only on specific halal industry sectors or supply chains (see Table 1). Our study is among the first to comprehensively analyze the literature related to technological innovation in the halal industry using the PRISMA methodology. Furthermore, the significance of this study lies in its identification of not only the characteristics already described in past studies but also in its identification of the research gaps in this field.

Research Methods

In this study, we followed the PRISMA guidelines to compile our review (Higgins & Green, 2008). Systematic reviews frequently exhibit a lack of awareness of shared guidelines, which is essential for ensuring replicability and scientific adequacy (Moher et al., 2010). PRISMA offers a standard methodology that is widely accepted by peer reviewers and includes a comprehensive checklist (Pussegoda et al., 2017). We strictly followed this checklist in the preparation of this paper to ensure quality assurance in the review process and enhance its replicability.

Furthermore, we developed a detailed review protocol that outlined the search strategy, article selection criteria, data extraction procedures, and data analysis methods (Denyer & Tranfield, 2014). This protocol was meticulously designed to ensure that each step of the review process was systematically and consistently conducted. By employing the PRISMA methodology, we aimed to enhance the transparency and validity of our review's findings, thereby contributing more reliably and robustly to the research field. This rigorous process not only strengthens the quality of the review but also ensures that the results can be trusted and replicated by other researchers.

However, it is crucial to consider the implications and limitations of applying the PRISMA methodology, especially in the context of analyzing diverse topics, such as technological advancements in the halal industry. While PRISMA ensures a structured and transparent approach, potential biases arise from the methodological choices. For instance, the exclusion of Google Scholar and restriction to English-language publications while ensuring quality and focus may have limited the scope of the study by omitting valuable non-English regional research. To enhance transparency and collaboration during the review process, we utilized WATASE UAKE, a tool that facilitates systematic data extraction and collaborative analysis among coauthors to ensure consistency and reduce individual biases.

Data sources and search strategies

The Scopus database was used in this study because of its advantages. Numerous factors support the use of the Scopus database for literature compilation: (1) it is the largest collection of abstracts and citation information globally, (2) timely updates are maintained regularly, (3) there is flexibility in both debugging and data processing, and (4) it offers exceptional coverage and indexing of relevant journals (Bosman et al., 2006). Scopus is highly comprehensive for search purposes because of its ability to narrow down search strings using the 'OR' and 'AND' operators. The utilization of search engines, such as Google Scholar, was avoided because of its challenging nature in extracting the desired material. The search was conducted using the following keywords: "Halal" AND "technology" OR "digital" OR "IoT" OR "blockchain" OR "AI" between the years 2014 and 2024. To conduct a thorough search, the scope was restricted to papers published in English. This decision was made because English is the predominant language for publications on the halal industry, as indicated by searches performed on multiple search engines.

Selection of study

The objective of this strategy is to optimize the probability of retrieving pertinent documents. It is important to emphasize that the use of a search string does not ensure that only papers directly relevant to the research topic are retrieved. Consequently, exclusion criteria were defined. The screening technique included evaluating the titles and abstracts of the retrieved publications according to these criteria (Lewandowski, 2015). The objective was to exclude publications that did not correspond to the examined subject area. Figure 2 presents the specific exclusion criteria and associated number of papers. The initial limitation of journal papers was based on the observation that high-quality research is typically published in reputable journals and undergoes peer review. However, because research on the halal industry is considered an emerging area, conference proceedings have also been included.

Following the application of the exclusion criteria, the titles of the articles were further utilized to eliminate papers based on their pertinence to the study objectives. The subsequent criteria employed perused the abstracts, followed by a thorough examination of the papers to identify pertinent papers, as outlined in Figure 2. A significant number of results were excluded after applying the research discipline exclusion criteria owing to the consideration of many aspects of the halal industry that are beyond the scope of this work. Once an adequate number of pertinent literature sources were gathered according to the defined criteria, the papers were subsequently examined and evaluated, as demonstrated in the results and discussion section.
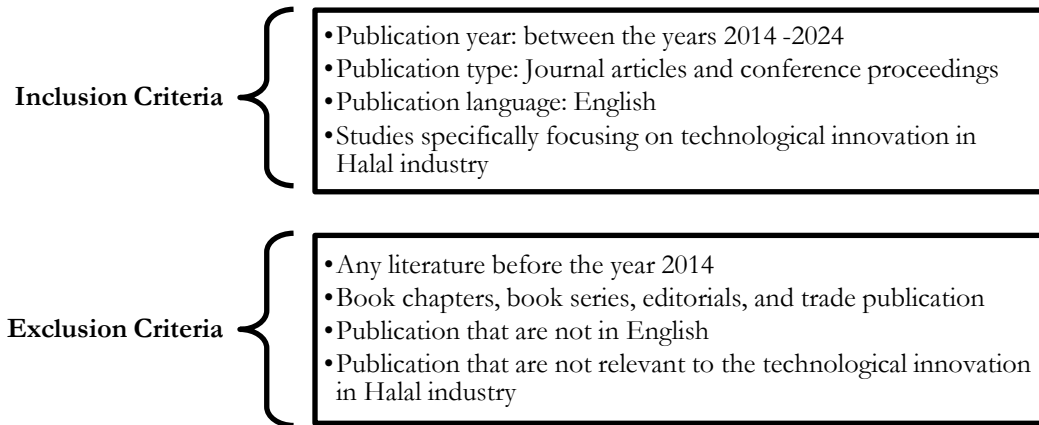
Inclusion Criteria
- Publication year: between the years 2014 -2024
- Publication type: Journal articles and conference proceedings
- Publication language: English
- Studies specifically focusing on technological innovation in Halal industry

Exclusion Criteria
- Any literature before the year 2014
- Book chapters, book series, editorials, and trade publication
- Publication that are not in English
- Publication that are not relevant to the technological innovation in Halal industry

Figure 2. Inclusion and exclusion criteria

Data extraction

Following the initial exclusion of papers based on their titles and abstracts, 54 studies remained for further consideration. The first author evaluated these studies, assessing their titles, abstracts, and full texts to determine their relevance according to the predefined inclusion and exclusion criteria. Whenever there was any uncertainty regarding the eligibility of a study, the second author independently reviewed the questionable papers to provide an additional perspective. Subsequently, the two authors engaged in detailed discussions to deliberate the eligibility of these studies, aiming to reach a consensus on each publication. Through this collaborative process, the final selection of 54 studies was determined, as shown in Figure 3.
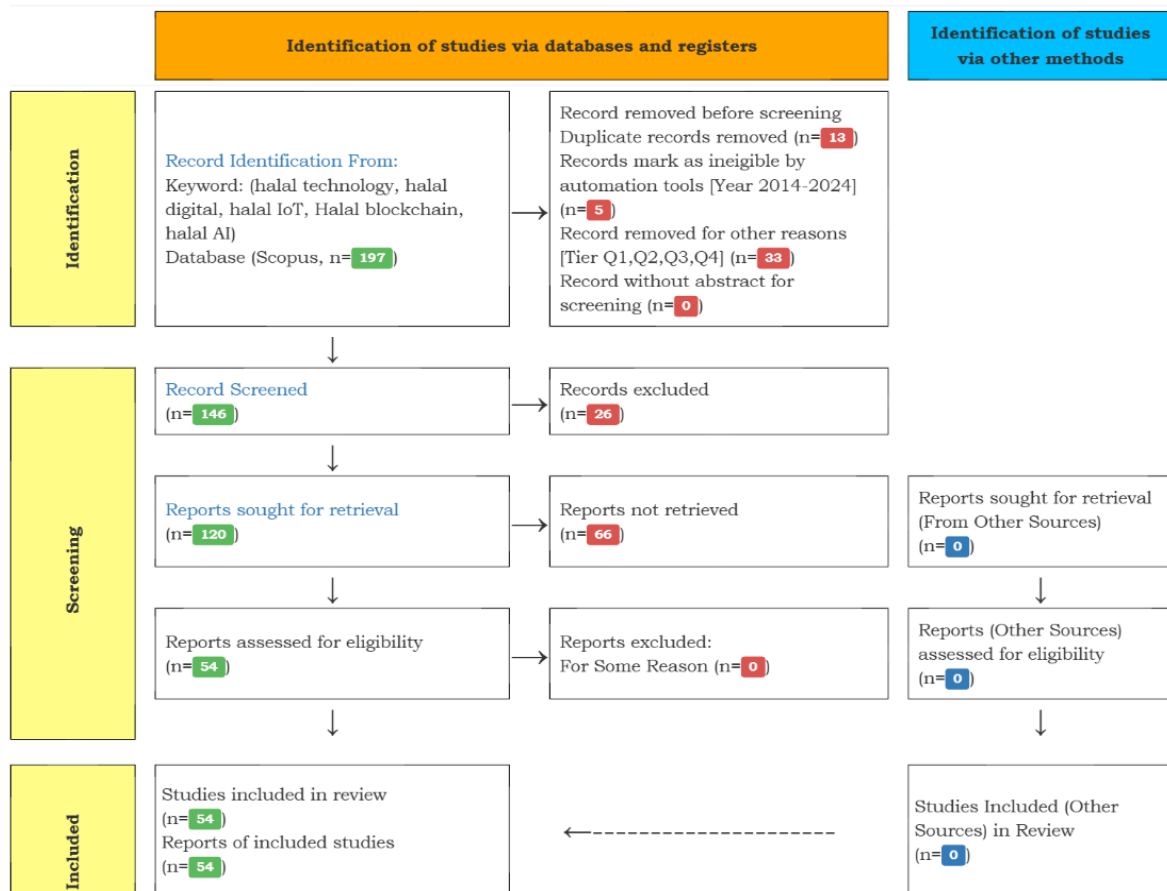
Figure 3. PRISMA flowchart

Figure 3, the PRISMA flowchart, outlines the sequential steps taken during the study selection process, starting with the identification of 197 initial records and ending with 54 articles after applying strict inclusion and exclusion criteria. This rigorous selection highlights the systematic nature of the review but also underscores the niche and emerging nature of the research topic. The limited number of articles included, while sufficient to provide meaningful insights, may affect the generalizability of the findings. Future studies could broaden the search criteria to encompass a wider range of studies, potentially increasing the reliability and validity of the results.

Data analysis procedures

The shortlisted studies identified through the review process were further analyzed and discussed in the subsequent section of this report. The selected literature was systematically categorized and synthesized based on various criteria, including publication trends, sources, geographical locations, research methodologies, theoretical perspectives, and themes or factors derived from the literature.

Following PRISMA methodology, 54 articles were selected for review and synthesis. Despite the relatively small number of review papers, this sample is sufficient to provide meaningful insights into the current state of technological innovation in the halal industry. Robinson and Lowe (2015) note that such a small yield is typical in systematic literature reviews because multiple layers of screening and filtering are involved.

In this section, the authors report on the trends and synthesize the findings from the 54 reviewed academic articles. A subsequent subsection highlights the current state of research on technological innovation in the context of the halal industry.

Results and Discussion

Descriptive analysis

The descriptive results provide a comprehensive overview and highlight the foundational approaches and attributes utilized by the selected studies (Lettieri et al., 2009). Consequently, this investigation should focus on examining the specific timeframes during which these articles were published. The primary objective of period-wise distribution analysis was to determine the annual number of articles that met the review criteria. As shown in Figure 4, there has been a noticeable increase in the number of publications each year, from 2014 to 2024, suggesting a growing academic focus on this specific field of research. In the academic community over the last ten years, there has been a growing acknowledgement and investigation of this subject. Notables are 2018, 2021, and 2022, during which there was a substantial increase in the number of publications. These high points indicate times of increased research interest, possibly influenced by new trends, discoveries, or changes in the relevance of the topic in academia and practice.

By examining these patterns in publications, the analysis offers important insights into how research in this area is changing over time, pointing out times of increased scholarly involvement, and setting the stage for understanding the factors that influence these trends.
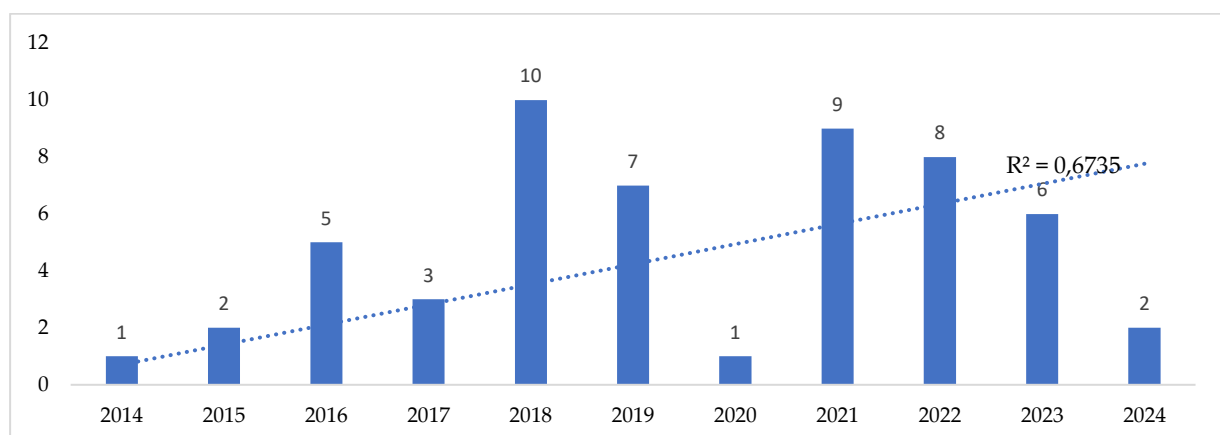

Figure 4. Publication trends

The descriptive analysis of the word cloud serves as a foundation for understanding the thematic landscape of technological integration in the halal industry and sets the stage for examining trends in the publication of related research papers. The word cloud highlights key themes and concepts related to the integration of technological innovation in the halal industry, emphasizing the increasing adoption and impact of technology in enhancing the global halal sector. Several keywords appeared, including blockchain, halal food, halal tourism, halal industry, and halal supply chain.

Blockchain technology is prominent, indicating its crucial role in ensuring transparency, traceability, and integrity in halal supply chains. By providing immutable records, blockchain helps to verify the halal status of products from production to consumption, thus building consumer trust (Alamsyah et al., 2022). Halal food is the most frequently mentioned sector, demonstrating extensive research and development efforts to ensure that food products meet halal standards through advanced technological solutions, such as IoT devices, smart packaging, and food safety monitoring systems (Akbar et al., 2022; Chandra et al., 2019).

The Integration of technology in halal tourism includes mobile applications for Muslim travelers, providing services such as prayer time notifications, halal restaurant locators, digital Qibla directions, enhancing the overall travel experience, and ensuring compliance with halal requirements (Battour et al., 2023). Technologies such as RFID, GPS, and blockchain are revolutionizing the halal supply chain by enabling the efficient management, tracking, and authentication of halal products, ensuring that they remain uncontaminated and halal-compliant throughout the supply chain (Suseno et al., 2023).

Figure 5 illustrates the dynamic interplay between technological advancements and the halal industry, showing how innovations are transforming various sectors to meet the evolving demands of Muslim consumers globally and emphasizing the importance of adopting modern technologies to maintain the integrity, efficiency, and growth of the halal industry in an increasingly digital world.

Figure 5. Word cloud

Methodological analysis

After examining the methodologies used in the reviewed publications presented in Figure 6, it is clear that a large portion of the research has focused on qualitative analysis techniques. Specifically, 22 articles utilized qualitative methods, focusing on non-numerical data and aiming to provide an in-depth, contextual understanding of the topics through interviews, focus groups, or content analysis.
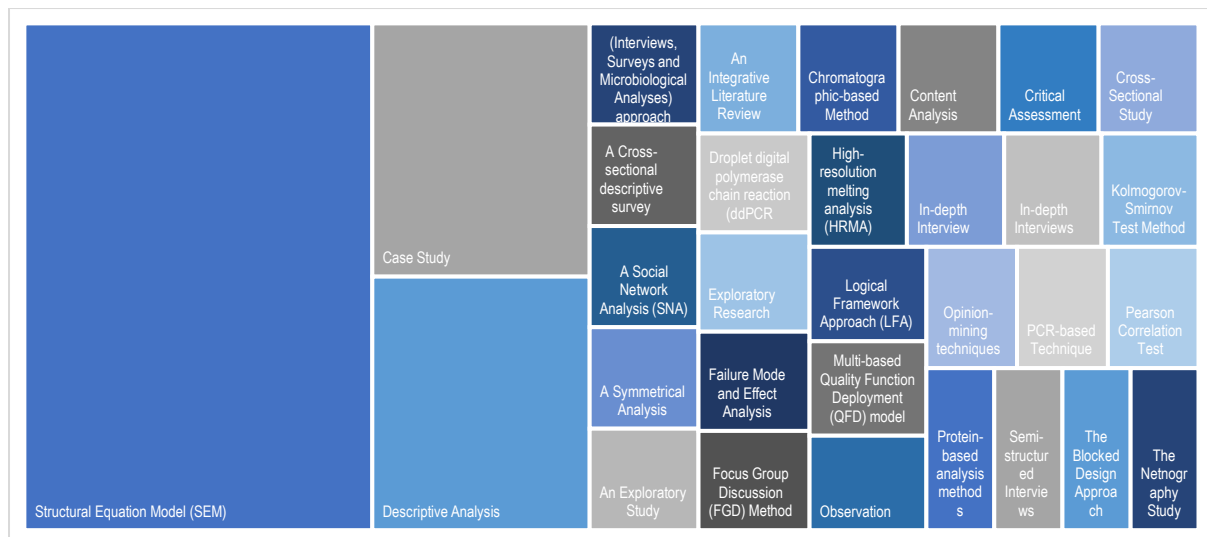
Figure 6. Publications based on the Methodology Used

In contrast, a slightly larger group of 26 articles employed quantitative methods that involved numerical data and statistical analysis, and aimed to quantify variables and uncover patterns or correlations through surveys, experiments, or other measurable forms of data collection.

The remaining articles used mixed-methods approaches, combining both qualitative and quantitative techniques to leverage the strengths of both paradigms and provide a more comprehensive perspective on the research questions. These studies integrated diverse methodologies to explore the complexity of their subjects more thoroughly, drawing on numerical data to support qualitative insights and vice versa.

Overall, the distribution of methodologies in the reviewed publications balanced the qualitative and quantitative analyses, with a thoughtful integration of mixed methods in several studies.

Country analysis

Figure 7 shows the distribution of studies by country, reflecting each country's interest in the halal industry. Indonesia and Malaysia are recognized as leaders in the halal industry, especially when integrating technological innovation. These countries are at the forefront of halal industry research with advanced business ecosystems, as noted by Baran (2021), Haleem et al. (2020), and Rusydiana (2023). According to Talib (2021), Malaysia and Indonesia are pivotal drivers of the global halal economy, serving as models for other countries.
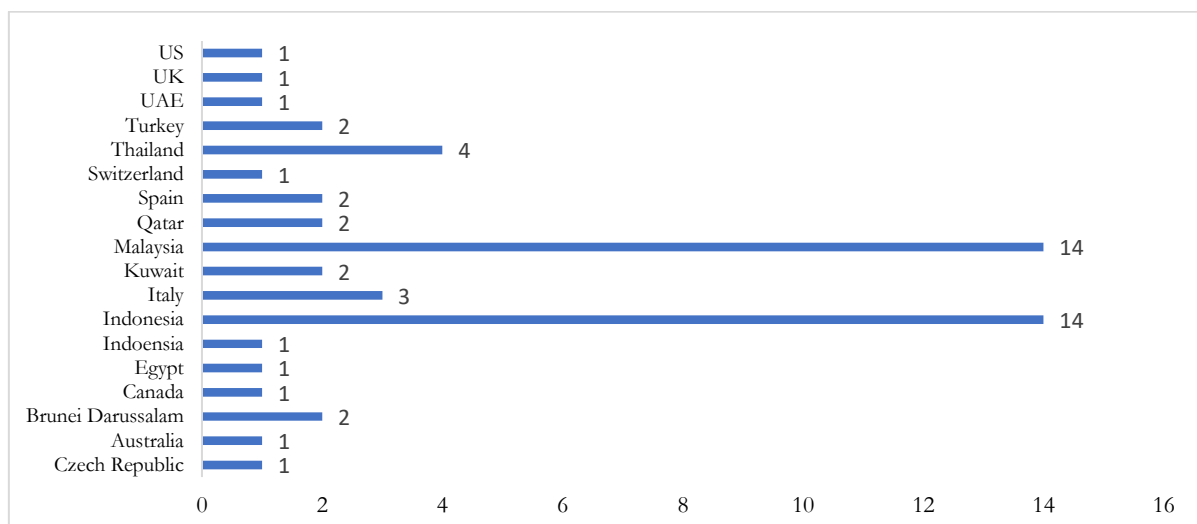

Figure 7. Distribution of publications by country

Although research on halal technological innovation is still new, the progress made by these two countries in several sectors of the halal industry is promising. These advancements highlight the dynamic nature of the halal industry and the importance of technological innovation for growth and sustainability. This progress not only benefits their domestic markets but also contributes to the global halal economy, setting benchmarks for other nations.
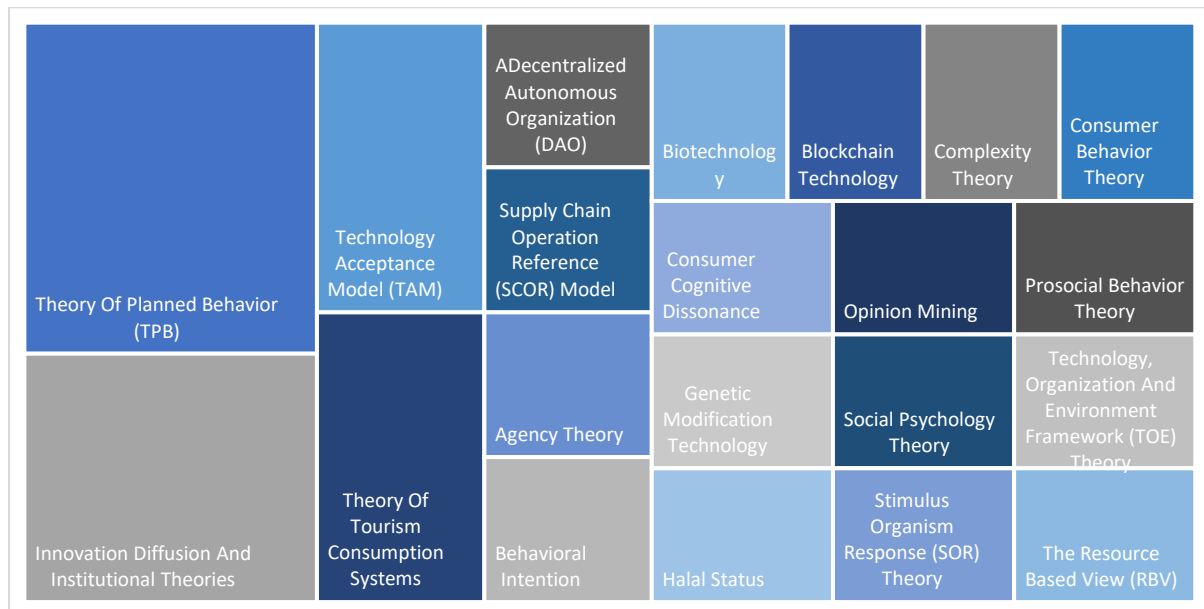
Theoretical analysis

Figure 8. Theory/model used in past studies

In research exploring the integration of the halal industry and technological innovation, several prominent theories are frequently used to explain and analyze the observed phenomena (see Figure 8). The theory of planned behavior (TPB) is the most commonly applied theory and is featured in four studies. TPB, a social psychology theory, elucidates the connection between beliefs and behavior. This helps researchers understand how attitudes, subjective norms, and perceived behavioral control influence intentions and actual behavior, providing insights into the psychological factors driving industry players to adopt new technologies within the halal framework.

Innovation diffusion and institutional theories are also prominent and appear in three studies. The diffusion of innovation theory focuses on the spread of new ideas and technologies through cultures, whereas institutional theory delves into the influence of social structures on organizational behavior. These theories are particularly valuable for understanding how technological innovations can be widely adopted in industries heavily influenced by religious norms and regulations, such as halal.

Furthermore, the technology acceptance model (TAM) is employed in two studies. TAM concentrates on how users come to accept and use technology, emphasizing perceived usefulness and ease of use as the main factors determining technology acceptance. In the context of the halal industry, TAM is used to analyze industry players' perceptions of new technologies, assess whether they view them as beneficial and easy to use, and guide their decisions to adopt these technologies.

In conclusion, the various theories used in research on the integration of the halal industry and technological innovation demonstrate a comprehensive approach to understanding technology adoption in this specific context.

Technology in the halal industry: IoT, Blockchain, and AI

The integration of technology in the halal industry is essential for improving efficiency, transparency, and sustainability in different sectors of the market. Technology provides creative solutions for important issues such as traceability, compliance, and supply chain management, as

the worldwide need for halal products increases (Alamsyah et al., 2022). Technologies such as IoT, Blockchain, and AI are crucial for maintaining the authenticity of halal products and services, as well as improving efficiency in industries such as food, pharmaceuticals, cosmetics, and tourism. For example, IoT solutions enable live tracking of halal supply chains, ensuring that each production stage meets halal guidelines from the farm to the consumer's plate. Blockchain increases consumer trust by ensuring transparency through the permanent record of every transaction and stage in the supply chain (Mohamed et al., 2020). Implementing artificial intelligence allows businesses to forecast market patterns, enhance operations, and streamline tasks, such as halal certification and quality control, ultimately decreasing errors and improving efficiency and precision (Ali et al., 2021; Wahyuni et al., 2024).

Advanced technologies have been implemented in the food industry to meet the demands for stringent halal certification. Blockchain technology is extensively utilized in the halal food supply chain to monitor and authenticate the halal status of products throughout all stages from manufacturing to consumption. Along with tracking capabilities, AI also plays a vital role in quality assurance by detecting nonhalal components or pollutants in food items. Denyingyhot et al. (2021) explained how AI-based high-resolution melting analysis (HRMA) can promptly identify contamination, guaranteeing adherence to halal guidelines. In addition to the food industry, the halal pharmaceutical and cosmetic sectors utilize technologies such as AI and blockchain for ingredient verification, certification, and supply chain integrity to align with Islamic principles (Norazmi & Lim, 2015).

Incorporating technology into the halal market is essential for promoting a sustainable halal ecosystem. The development of a sustainable halal market necessitates the following religious principles, as well as environmental and ethical standards: IoT and AI technologies improve the efficiency of halal supply chains by optimizing resource use, reducing waste, and enhancing the overall performance. Blockchain also contributes to sustainability by increasing transparency and accountability, guaranteeing that all participants in the halal supply chain will follow sustainable practices (Alamsyah et al., 2022). AI-powered platforms customize the travel journey for Muslim travelers in the field of halal tourism, as blockchain boosts the reliability of halal-compliant lodging and amenities. Finally, the extensive use of these technologies helps develop a sustainable halal market by maintaining halal standards, enhancing operational efficiencies, and building consumer trust in halal products and services (Battour et al., 2023; Tan et al., 2022).

Opportunities and challenges of technological innovation in the halal industry

Firms must recognize the various opportunities and challenges that technological innovation can present to the halal industry. Without a clear short-term plan, companies face the danger of ineffective technology integration and could miss out on the opportunity to fully embrace innovations, such as IoT, Blockchain, and AI, in the halal industry. Businesses must prioritize research, development, and investment in these technologies when the benefits exceed obstacles. Recognizing the possible dangers that could affect technology uptake will lead to improved preparation and seamless business changes. Table 2 summarizes the opportunities and challenges of technological advances in the halal sector, based on the key themes identified in the 54 articles examined.

Table 2. Opportunities and challenges of technological innovation in the halal industry

Sub	Opportunities	Challenges	Reference
Blockchain in Halal Industry	Blockchain enhances transparency and traceability in the halal food supply chain.	High cost and complex infrastructure needed for blockchain adoption.	Wahyuni et al. (2024)
Blockchain in Halal Supply Chain	Sustainable blockchain framework improves transparency and trust in the halal food supply chain.	Adopting blockchain in developing countries faces high costs and technology understanding.	Ali et al. (2021)

Sub	Opportunities	Challenges	Reference
AI in Halal Tourism	AI helps enhance Muslim-friendly tourism by customizing services according to consumer needs.	Lack of AI awareness and expertise in integrating AI into services for halal tourism.	Battour et al. (2022)
IoT and Blockchain in Halal	Blockchain and IoT allow for better food traceability and quality control in the halal sector.	High initial costs and lack of clear government regulations for full-scale implementation.	Tan et al. (2020)
Halal Certification using DNA	DNA-based approaches can authenticate halal status more effectively.	Requires advanced lab technologies that are costly and inaccessible to small-scale producers.	El Sheikha et al. (2017)
Blockchain-empowered Fashion	Blockchain in the halal fashion industry improves authenticity verification, supporting global market growth.	Technical expertise and infrastructure challenges in implementing blockchain for halal fashion traceability.	Sumarliah et al. (2021)
Blockchain and Halal Integrity	Halal supply chain management with blockchain ensures integrity and certification compliance throughout the food chain.	The challenge of managing a fragmented supply chain in halal food with limited technological adoption.	Mohamed (2020)
Halal in Global Market	Blockchain and traceability enhance halal product competitiveness in global markets, increasing consumer confidence.	Implementing blockchain globally can be restricted by regulatory differences and technological readiness across countries.	Al-Kwifi et al. (2019)
Halal Pharmaceutical Industry	Technological advances open opportunities for halal pharmaceutical certification and increase global market reach.	Complexities in halal pharmaceutical certification across countries create challenges for technology integration.	Norazmi & Lim (2015)
Analytical Technologies for Halal	Analytical technologies verify the authenticity of halal foods and improve consumer trust.	Adoption of these technologies is costly and may be difficult for smaller firms.	Kua et al. (2022)
Halal Meat Industry	Multi-based quality function deployment models enhance the efficiency of halal meat supply chain and ensure halal integrity.	Lack of standardization and high investment costs in adopting advanced technology within the halal meat industry.	Vanany et al. (2019)
Halal Certification Challenges	Blockchain adoption enhances the halal supply chain's performance and competitive edge.	Challenges in ensuring proper certification and technical alignment with halal standards in developing countries.	Hendayani & Fernando (2022)
Halal Tourism and Blockchain	Blockchain and certification processes support sustainable halal tourism.	Lack of clear guidelines for blockchain integration in halal tourism and high infrastructure costs.	Bux et al. (2022)
Halal SME and Innovation	Innovation mindset and blockchain boost competitiveness and halal certification processes for SMEs in energy-intensive industries.	Limited adoption due to high initial costs and lack of technical knowledge among SMEs.	Jaaffar et al. (2024)
Halal Food and Blockchain	Blockchain ensures accurate tracking and transparency from farm to plate in halal food production.	Resistance to adopting new technology and high costs of blockchain deployment in the halal food sector.	Lubis et al. (2016)
Halal Logistics in ASEAN	Digitally-enabled logistics improve the performance of the halal supply chain in	Fragmented logistics networks and inconsistent regulations across ASEAN nations make technological adoption difficult.	Hidayat & Musari (2022)

Sub	Opportunities	Challenges	Reference
Halal Food Supply Chain	ASEAN, supporting regional market integration. Blockchain traceability improves halal integrity assurance for the food industry, reducing contamination risks.	The technological complexity of blockchain systems makes implementation challenging for less developed food industries.	Azmi et al. (2020)
Halal Industry Post Covid-19	Digital technology adoption post-Covid-19 enhances the halal industry's capacity to adapt to changes and improve supply chain resilience.	The challenge of managing technology integration in response to changing consumer preferences and post-pandemic shifts in the industry.	Hidayat et al. (2022)

Utilizing the IoT, blockchain, and AI in the halal industry brings about substantial challenges and opportunities. Integrating these technologies into existing halal processes poses a significant challenge because of their complexity and high costs, particularly for small- and medium-sized enterprises (SMEs) that are crucial to various industries in Indonesia. Numerous small and medium-sized enterprises (SMEs) may find it challenging to afford the necessary infrastructure and technical knowledge to integrate IoT and blockchain technologies, even though they provide advantageous long-term benefits (Tan et al., 2020). Furthermore, concerns regarding data privacy and security arise owing to the handling of significant amounts of sensitive data related to halal certification and supply chain tracking by blockchain and IoT systems. Another significant hurdle is ensuring that regulatory requirements are met, especially in nations where halal-certifying organizations may not have comprehensive regulations for incorporating these modern technologies (Agung et al., 2024).

Nevertheless, there are many possibilities for growth. One key advantage of blockchain technology is its ability to increase transparency and traceability in the production of halal food, which is crucial in countries like Indonesia with a large Muslim population. By recording every step of the supply chain on a secure and unalterable ledger, companies can ensure the quality of halal products, maintain consumer trust, and meet religious standards (Wahyuni et al., 2024). AI can enhance effectiveness with predictive analytics, enabling businesses to optimize various operations, including supply chain management and customized customer services, particularly in halal tourism (Battour et al., 2023). In the digital era following the pandemic, e-commerce platforms utilizing AI and blockchain technology can provide halal businesses with more opportunities in the global market, boosting their competitiveness (Wang et al., 2022).

To tackle these difficulties, halal companies must provide training for their employees to acquire the technical expertise needed to handle emerging technologies. This might require collaboration with schools and tech companies to develop specific initiatives. Additionally, halal enterprises may consider forming partnerships with technology companies and certification organizations to manage the challenges of meeting regulatory requirements and certification criteria (Ali et al., 2021). Gradually implementing projects in phases, beginning with pilot tests, can assist businesses in cost management and the early detection of issues before expansion. Searching for funding options such as government grants or private sector investments can help small and medium-sized enterprises reduce their financial strain.

Governments in areas such as Indonesia have played a crucial role in this change. They ought to create favorable strategies that promote the adoption of technology by providing financial benefits, such as subsidies or low-interest loans, to help businesses with initial expenses (Rajiani et al., 2023). Businesses should have clear guidelines on data security and halal certification to confidently embrace new technologies. Collaborations between the public and private sectors have the potential to boost creativity and offer companies the support necessary to thrive in the evolving digital age. In conclusion, raising consumer awareness of the advantages of these technologies, especially in maintaining halal authenticity, can help encourage acceptance and boost the expansion of the industry (Azman et al., 2020). Through strategic investment, collaboration, and government support, the halal sector can realize the full potential of technological innovation and maintain its competitiveness and sustainability in the global market.

Future research

Owing to the remarkable growth of the halal sector and its promising prospects, the incorporation of digitalization and technological advancements is unavoidable. Incorporating technologies such as IoT, blockchain, and AI is increasing transparency, traceability, and authenticity in halal products. Acknowledging the significance of these technologies, scholars and practitioners can be guided by a future research agenda grounded in the TCM framework (Theory, Context, Methodologies) (Kajol et al., 2022).

Regarding Theory, future research should concentrate on creating thorough theoretical models that combine digital technologies with halal standards. This may mean expanding Technological Spillover Theory to include elements pertinent to the halal sector or developing fresh frameworks for handling the distinct needs of halal certification and adherence in a digital setting. Moreover, delving deeper into the theory of acceptance and use of technology (UTAUT) and the technology acceptance model (TAM) within the realm of halal product traceability and authenticity may offer valuable insights into how these theories relate to the adoption of IoT, blockchain, and AI technologies by halal consumers and producers.

In this Context, it is crucial to conduct comparative studies in various regions to comprehend how cultural and regulatory factors impact the integration of digital technologies in the halal sector. Studying how digital technologies are utilized in different areas of the halal industry, such as halal food manufacturing, beauty products, medicines, and clothing, will provide a detailed understanding of the effects of digitalization on the wider halal ecosystem.

In terms of methodologies, it is beneficial to continue using tools such as PRISMA for systematic literature reviews because they can assist in monitoring new trends, pinpointing areas for further research, and offering a thorough understanding of the current body of knowledge. Using a combination of qualitative methods, such as interviews, focus groups, and case studies, along with quantitative methods, such as surveys and experiments, will provide a more comprehensive understanding of how digital technologies are being adopted and their impact on the halal industry. Observing the impacts of digitalization on the halal industry through longitudinal studies that track technological adoption, consumer behavior, regulatory changes, and market dynamics over time can help identify trends and predict future developments.

Conclusion

The research shows a noteworthy rise in yearly publications from 2014 to 2024 within the realm of technology integration in the halal industry, demonstrating an increasing scholarly focus on this subject. The word cloud analysis also shows how technologies such as blockchain and IoT enhance the transparency and traceability of halal products and their significant impact on halal food, tourism, and supply chain industries. This study found that combining qualitative and quantitative methods effectively in researching the integration of the halal industry and technological innovation offers thorough insights. Indonesia and Malaysia, as key players in the halal sector, play a pivotal role in driving technological advancements in the halal industry, thus substantially impacting the global halal economy. We also found that the three most-used theories in the literature are the Theory of Planned Behavior (TPB), Innovation Diffusion and Institutional Theories (IDIT), and the Technology Acceptance Model (TAM), which collectively enhance the understanding of technology adoption in the halal industry. The results highlight the crucial role of technology in aiding the expansion and longevity of the halal sector and lay the groundwork for future studies to enhance the utilization of this technology using advanced strategies.

From the conclusions drawn in this study, various important suggestions can be made concerning the opportunities and challenges of integrating technological advancements in the halal sector. Initially, it is crucial for enterprises, particularly small- and medium-sized ones, to put resources into capacity-building programs, such as employee training and partnerships with tech companies, to close the technical knowledge disparity. It is advisable to use a phased implementation approach to control expenses and mitigate the risks related to the integration of the IoT, blockchain, and AI technologies. Moreover, governments and regulatory bodies need to

actively develop favorable structures, provide financial benefits such as subsidies or grants, and set clear rules for data security and halal certification procedures. Public-private partnerships can also help drive innovation and encourage the use of these technologies within the halal industry. Finally, it is essential to raise consumer awareness of the advantages of these technologies in order to establish trust and promote widespread acceptance.

Acknowledgements

Author contributions

Conceptualization: Ririn Riani
Data curation: Ihsanul Ikhwan
Formal analysis: Ririn Riani
Investigation: Ririn Riani
Methodology: Ririn Riani
Project administration: Ihsanul Ikhwan
Supervision: Aam Slamet Rusydiana
Validation: Ririn Riani
Visualization: Ririn Riani
Writing – original draft: Ririn Riani, Ihsanul Ikhwan
Writing – review & editing: Ririn Riani

References

Abdillah, A., Widianingsih, I., Buchari, R. A., Mustari, N., & Saleh, S. (2022). Governance and Quintuple Helix innovation model: Insights from the local government of East Luwu Regency, Indonesia. *Frontiers in Climate, 4,* 1-15 https://doi.org/10.3389/fclim.2022.1012108

Agung, A. A. G., Yuniar, I., & Hendriyanto, R. (2024). Smart contract and IPFS decentralized storage for halal certification process. *International Journal on Informatics Visualization, 8*(1), 79–87. https://doi.org/10.62527/joiv.8.1.1497

Akbar, A., Rakhmawati, N. A., & Vanany, I. (2022). Halal blockchain application for a chicken slaughtering factory. *International Journal on Food System Dynamics, 13*(3), 321–334. https://doi.org/10.18461/ijfsd.v13i3.C6

Alamsyah, A., Hakim, N., & Hendayani, R. (2022). Blockchain-based traceability system to support the Indonesian halal supply chain ecosystem. *Economies, 10*(6). https://doi.org/10.3390/economies10060134

Ali, M. H., Chung, L., Kumar, A., Zailani, S., & Tan, K. H. (2021). A sustainable blockchain framework for the halal food supply chain: Lessons from Malaysia. *Technological Forecasting and Social Change, 170*, 120870. https://doi.org/10.1016/j.techfore.2021.120870

Al-Kwifi, O. S., Abu Farha, A., & Ahmed, Z. U. (2019). Dynamics of Muslim consumers' behavior toward halal products: Exploration study using fMRI technology. *International Journal of Emerging Markets, 14*(4), 689-708. https://doi.org/10.1108/IJOEM-11-2017-0486

Azam, M. S. E., & Abdullah, M. A. (2020). Global halal industry: Realities and opportunities. *International Journal of Islamic Business Ethics, 5*(1), 47. https://doi.org/10.30659/ijibe.5.1.47-59

Azman, N. H. N., Zabri, M. Z. M., Masron, T. A., & Malim, N. A. K. (2020). The utilisation of Islamic Fintech (I-Fintech) in promoting sustainable inclusive growth: Evidence from micro-entrepreneurs in Malaysia. *Journal of Islamic Monetary Economics and Finance, 6*(3), 555–576. https://doi.org/10.21098/jimf.v6i3.1180

Azmi, F. R., Abdullah, A., Musa, H., & Wan Mahmood, W. H. (2020). Perception of food manufacturers towards adoption of halal food supply chain in Malaysia: Exploratory factor analysis. *Journal of Islamic Marketing*, *11*(3), 571-589. https://doi.org/10.1108/JIMA-12-2018-0236

Baran, T. (2021). A literature review and classification of the studies on "halal" in Islamic business journals (2010-2018). *Journal of Islamic Marketing*, *12*(5), 1012-1024. https://doi.org/10.1108/JIMA-10-2019-0206

Barth, T. D. (2011). The idea of a green new deal in a Quintuple Helix Model of knowledge, know-how and innovation. *International Journal of Social Ecology and Sustainable Development, 2*(1), 1–14. https://doi.org/10.4018/jsesd.2011010101

Battour, M., Mady, K., Salaheldeen, M., Elsotouhy, M., Elbendary, I., & Boğan, E. (2023). AI-enabled technologies to assist Muslim tourists in halal-friendly tourism. *Journal of Islamic Marketing, 14*(5), 1291–1309. https://doi.org/10.1108/JIMA-01-2022-0001

Bosman, J., Mourik, I. V., Rasch, M., Sieverts, E., & Verhoeff, H. (2006). Scopus reviewed and compared: The coverage and functionality of the citation database Scopus, including comparisons with Web of Science and Google Scholar. Utrecht University Library. https://dspace.library.uu.nl/handle/1874/18247

Bux, C., Varese, E., Amicarelli, V., & Lombardi, M. (2022). Halal food sustainability between certification and blockchain: A review. *Sustainability*, *14*(4), 2152. https://doi.org/10.3390/su14042152

Carayannis, E. G., Barth, T. D., & Campbell, D. F. (2012). The Quintuple Helix innovation model: Global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship, 1*(1), 2. https://doi.org/10.1186/2192-5372-1-2

Chandra, G. R., Liaqat, I. A., & Sharma, B. (2019). Blockchain redefining: The halal food sector. *Proceedings - 2019 Amity International Conference on Artificial Intelligence, AICAI 2019*, February, 349–354. https://doi.org/10.1109/AICAI.2019.8701321

Denyer, D., & Tranfield, D. (2014). Using qualitative research synthesis to build an actionable knowledge base. *Management Decision, 44*(2), 213–227. https://doi.org/10.1108/00251740610650201

Denyingyhot, A., Phraephaisarn, C., Vesaratchavest, M., Dahlan, W., & Keeratipibul, S. (2021). A new tool for quality control to monitor contamination of six non-halal meats in food industry by multiplex high-resolution melting analysis (HRMA). *NFS Journal, 25*, 31–40. https://doi.org/10.1016/j.nfs.2021.09.002

DinarStandard. (2023). *State of the global Islamic economy report 2023/24*. Dubai: Salaam Gateway. https://www.salaamgateway.com

El Sheikha, A. F., Mokhtar, N. F. K., Amie, C., Lamasudin, D. U., Isa, N. M., & Mustafa, S. (2017). Authentication technologies using DNA-based approaches for meats and halal meats determination. *Food Biotechnology*, *31*(4), 281-315. https://doi.org/10.1080/08905436.2017.1369886

Haleem, A., Khan, M. I., Khan, S., & Jami, A. R. (2020). Research status in halal: A review and bibliometric analysis. *Modern Supply Chain Research and Applications, 2*(1), 23-41. https://doi.org/10.1108/MSCRA-06-2019-0014

Handayani, D. I., Masudin, I., Susanty, A., & Anna, I. D. (2024). Modeling of halal supplier flexibility criteria in the food supply chain using hybrid ISM-MICMAC: A dynamic perspective. *Cogent Engineering, 10*(1), 2219106. https://doi.org/10.1080/23311916.2023.2219106

Handayani, D. I., & Vanany, I. (2021, December). Blockchain application in halal supply chain: Literature review and future research. In *2021 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)* (pp. 1387-1391). IEEE. https://doi.org/10.1109/IEEM50564.2021.9673084

Harsanto, B., Farras, J. I., Firmansyah, E. A., Pradana, M., & Apriliadi, A. (2024). Digital technology 4.0 on halal supply chain: A systematic review. *Logistics, 8*(1). https://doi.org/10.3390/logistics8010021

Hasan, K. N. S., & Pasyah, T. (2022). Challenges of Indonesian halal industry in the digital economic era. *Sriwijaya Law Review, 6*(2), 319–335. https://doi.org/10.28946/slrev.Vol6.Iss2.869.pp319-335

Hastuti, A., Lestari, T. A., Fadilah, I., Hapsari, D. R., Mubarokah, S. L., Nurlaela, R. S., & Anwar, S. (2023). A bibliometric analysis of applied technology development of halal food sciences. *Journal of Engineering Science and Technology, 18*(4), 39–47. https://jestec.taylors.edu.my/Special%20Issue%20ISCoE%202022_3/ISCoE%203_05.pdf

Hendayani, R., & Fernando, Y. (2022). Adoption of blockchain technology to improve halal supply chain performance and competitiveness. *Journal of Islamic Marketing, 14*(9), 2343-2360. https://doi.org/10.1108/JIMA-02-2022-0050

Hidayat, S. E., & Musari, K. (2022). ASEAN towards a global halal logistics through the digitally enabled community. *International Journal of Asian Business and Information Management (IJABIM), 13*(2), 1-15. https://doi.org/10.4018/IJABIM.20220701.oa1

Hidayat, S. E., Rafiki, A., & Nasution, M. D. T. P. (2022). Halal industry's response to a current and post-Covid-19 landscape and lessons from the past. *Journal of Islamic Marketing, 13*(9), 1843-1857. https://doi.org/10.1108/JIMA-06-2020-0180

Higgins, J. P., & Green, S. (2008). *Cochrane handbook for systematic reviews for interventions.* Willey-Blackwell. http://www.radioterapiaitalia.it/wp-content/uploads/2017/01/cochrane-handbook-for-systematic-reviews-of-interventions.pdf

Jaaffar, A. H., Abd Majid, N., Kasavan, S., Isa, A., Alwi, M. N. R., & Zahari, A. R. (2024). The effect of innovative mindset and behavior on innovation performance and competitive advantage: A case of halal SMEs owner-managers from Malaysian energy-intensive industry. *Journal of Innovation and Entrepreneurship, 13*(1), 1. https://doi.org/10.1186/s13731-023-00359-z

Jalil, N. S., Norman, A. A., & Hamid, S. (2017). Studies on technology and halal food security: A review. *Pertanika Journal of Social Sciences and Humanities, 25*(December), 225–239. http://www.pertanika.upm.edu.my/resources/files/Pertanika%20PAPERS/JSSH%20Vol.%2025%20(S)%20Dec.%202017/19%20JSSH(S)-0574-2017.pdf

Kajol, K., Singh, R., & Paul, J. (2022). Adoption of digital financial transactions: A review of literature and future research agenda. *Technological Forecasting & Social Change, 184*, 121991. https://doi.org/10.1016/j.techfore.2022.121991

Kua, J. M., Azizi, M. M. F., Abdul Talib, M. A., & Lau, H. Y. (2022). Adoption of analytical technologies for verification of authenticity of halal foods–a review. *Food Additives & Contaminants: Part A, 39*(12), 1906-1932. https://doi.org/10.1080/19440049.2022.2134591

Lettieri, E., Masella, C., & Radaelli, G. (2009). Disaster management: Findings from a systematic review. *Disaster Prevention and Management: An International Journal*, *18*(2), 117-136. https://doi.org/10.1108/09653560910953207

Lewandowski, D. (2015). Evaluating the retrieval effectiveness of web search engines using a representative query sample. *Journal of the Association for Information Science and Technology, 66*(9), 1763–1775. https://doi.org/10.1002/asi.23304

Lubis, H. N., Mohd-Naim, N. F., Alizul, N. N., & Ahmed, M. U. (2016). From market to food plate: Current trusted technology and innovations in halal food analysis. *Trends in Food Science & Technology*, *58*, 55-68. https://doi.org/10.1016/j.tifs.2016.10.024

Mohamed, Y. H., Abdul Rahim, A. R., & Ma'aram, A. (2020). The effect of halal supply chain management on halal integrity assurance for the food industry in Malaysia. *Journal of Islamic Marketing, 12*(9), 1734–1750. https://doi.org/10.1108/JIMA-12-2018-0240

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma, T. (2010). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *International Journal of Surgery, 8,* 336–341. https://doi.org/10.1016/j.ijsu.2010.02.007

Noor, N. (2024). Technology acceptance model in halal industries: a systematic literature review and research agenda, *Journal of Islamic Marketing, 15*(11), 3156-3173. https://doi.org/10.1108/JIMA-02-2024-0077

Norazmi, M. N., & Lim, L. S. (2015). Halal pharmaceutical industry: Opportunities and challenges. *Trends in Pharmacological Sciences, 36*(8), 496–497. https://doi.org/10.1016/j.tips.2015.06.006

Pussegoda, K., Turner, L., Garritty, C., Mayhew, A., Skidmore, B., Stevens, A., Boutron, I., Sarkis-Onofre, R., Bjerre, L. M., Hróbjartsson, A., Altman, D. G., & Moher, D. (2017). Systematic review adherence to methodological or reporting quality. *Systematic Reviews, 6*(1), 1–14. https://doi.org/10.1186/s13643-017-0527-2

Rahman, M. M., & Ahmad, Z. (2024). Lifelong learning and technologic advancement in the halal industry: Navigating the digital age embracing technological advancements for lifelong learning. In *Embracing Technological Advancements for Lifelong Learning* (Issue May). https://doi.org/10.4018/979-8-3693-1410-4.ch009

Rahman, M. M., Ali, M. E., Hamid, S. B. A., Bhassu, S., Mustafa, S., Al Amin, M., & Razzak, M. A. (2015). Lab-on-a-chip PCR-RFLP assay for the detection of canine DNA in Burger Formulations. *Food Analytical Methods, 8*(6), 1598–1606. https://doi.org/10.1007/s12161-015-0090-1

Rajiani, I., Kot, S., Michałek, J. & Riana, I. G. (2023). Barriers to technology innovation among nascent entrepreneurs in deprived areas. *Problems and Perspectives in Management, 21*(3), 614-628. https://doi.org/10.21511/ppm.21(3).2023.48

Robinson, P., & Lowe, J. (2015). Literature reviews vs systematic reviews. *Australian and New Zealand Journal of Public Health, 39*(2), 103. https://doi.org/10.1111/1753-6405.12393

Rusydiana, A. S. (2023). How to develop halal industry in Indonesia: An expert based methodology. *Halal Food Studies, 1*(1). https://doi.org/10.58968/hfs.v1i1.450

Sumarliah, E., Li, T., Wang, B., Moosa, A., & Sackey, I. (2021). The impact of customer halal supply chain knowledge on customer halal fashion purchase intention. *Information Resources Management Journal (IRMJ)*, *34*(3), 79-100. https://doi.org/10.4018/IRMJ.2021070105

Suseno, B. D., Sutisna, S., Hidayat, S., & Basrowi. (2023). Halal supply chain and halal tourism industry in forming economic growth. *Uncertain Supply Chain Management, 11*(4), 1433–1440. https://doi.org/10.5267/j.uscm.2023.8.003

Talib, M. S. A. (2021). Identifying halal logistics constraints in Brunei Darussalam. *Journal of Islamic Marketing, 12*(6), 1145-1158. https://doi.org/10.1108/JIMA-09-2019-0189

Tan, A., Gligor, D., & Ngah, A. (2022). Applying blockchain for halal food traceability. *International Journal of Logistics Research and Applications, 25*(6), 947–964. https://doi.org/10.1080/13675567.2020.1825653

Taratori, R., Rodriguez-Fiscal, P., Pacho, M. A., Koutra, S., Pareja-Eastaway, M., & Thomas, D. (2021). Unveiling the evolution of innovation ecosystems: An analysis of Triple, Quadruple, and Quintuple Helix model innovation systems in European case studies. *Sustainability, 13*(14). https://doi.org/10.3390/su13147582

Vanany, I., Maarif, G. A., & Soon, J. M. (2019). Application of multi-based quality function deployment (QFD) model to improve halal meat industry. *Journal of Islamic Marketing, 10*(1), 97-124. https://doi.org/10.1108/JIMA-10-2017-0119

Wahyuni, H. C., Rosid, M. A., Azara, R., & Voak, A. (2024). Blockchain technology design based on food safety and halal risk analysis in the beef supply chain with FMEA-FTA. *Journal of Engineering Research.* https://doi.org/10.1016/j.jer.2024.02.002

Wang, Z., Li, M., Lu, J., & Cheng, X. (2022). Business innovation based on artificial intelligence and blockchain technology. *Information Processing and Management, 59*(1). https://doi.org/10.1016/j.ipm.2021.102759