Review

Digital Technology 4.0 on Halal Supply Chain: A Systematic Review

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Abstract: *Background*: The halal supply chain is a focused type of supply chain that ensures halal products throughout the entire process, from upstream to downstream. This paper aims to identify the innovative digital technology 4.0 utilized within the halal supply chain and understand its impact on firm performance, both financial and non-financial. *Methods*: A systematic review methodology was employed on the academic database of Scopus, resulting in 70 articles. We analyze the included articles with two main aspects that are of concern in this research, namely what technology is used in certain parts of the supply chain (procurement, manufacturing, distribution, and/or logistics), as well as the impact on firm performance (financial and/or non-financial); *Results*: Our findings reveal that the technologies widely used include blockchain technology, halal financial technology, and halal traceability system (RFID, IoT). *Conclusions*: Innovative digital technology has been implemented in the halal supply chain and has affected the firm's performance both financially and non-financially. Future research is suggested to focus on investigations regarding holistic technology integration, quantitative analysis to measure the specific financial performance of firms adopting digital technologies, and the feasibility and importance of technology adoption for Small and Medium Enterprises (SMEs) in the halal industry.

Keywords: halal supply chain; innovative digital technology 4.0; halal value chain; systematic review; HSCM; halal industry; halal production; halal logistics; technology; halal supply chain management

1. Introduction

The halal supply chain, as defined in the literature, pertains to the effective oversight of the movement of materials, information, and capital to guarantee that products adhere to halal (permissible) standards throughout the entire production process, from farm to fork [1]. This approach underscores the importance of stakeholder coordination and collaboration to enhance supply chain performance and generate value, all while upholding halal principles across the entire chain [2]. Halal supply chain is also called halal logistics in several studies (e.g., [3–5]), so these terms are used interchangeably. The fundamental significance of the halal supply chain lies in its role as a cornerstone, wherein the prevention of direct contact with forbidden elements, management of contamination risks, and alignment with the perceptions of Muslim consumers are pivotal aspects [6]. These objectives set the halal supply chain apart from the conventional or standard supply chain, establishing it as a distinctive and crucial component.

The significance of the halal supply chain is underscored by the vast market for halal products, particularly in Muslim-majority countries. The primary target audience for halal products, necessitating the implementation of a halal supply chain, is the global Muslim population of 1.6 billion individuals, concentrated mainly in Asia, the Middle East, and Africa. The global halal market currently exceeds two trillion U.S. dollars and is anticipated to grow to 2.8 trillion U.S. dollars in the future [7]. As of 2021, Islamic finance dominated the halal industry with a market share of 51.6%, showcasing the success of the sector in implementing the halal supply chain. Following closely was the halal food industry, holding 31.46% of the global halal market share [8]. These statistics highlight the increasing importance of the halal supply chain, attracting attention and interest from both industry practitioners and researchers.

Research within the scope of the halal supply chain interacts with several dominant perspectives, such as supply chain management, certification, and marketing. In relation to marketing, previous research highlights the need for figurative understanding and halal brand elements for organizations [9]. Furthermore, in supply chain management, researchers [10] emphasize the opportunities and challenges in halal logistics, showing the importance of developing existing research in this area [10]. In addition, the adoption of the technology-organization-environment (TOE) framework is proposed for the development of the Halal warehouse adoption model, underlining the importance of integrating technology, organization, and environmental factors in the halal supply chain [11].

The use of innovative technologies has been widely employed in the field of supply chain management, including the concept of smart supply chain management, which offers unprecedented opportunities for cost reduction and efficiency improvement through intelligent decision-making and automation capabilities [12]. Additionally, the application of decision support systems and intelligent systems can overcome the challenges of unpredictable demand and rapidly changing market trends in the textile and apparel industry supply chain [13]. From a wood supply chain perspective, the use of Discrete Event Simulation (DES) can facilitate testing alternative strategies and provide decision support for tactical and operational planning [14,15]. Furthermore, innovative digital technology is crucial to enhance the efficiency and effectiveness of company activities, including in their supply chain [16–18], more specifically in the halal supply chain.

Prior studies have highlighted digital technology's role in improving transparency, integrity, and certification processes in the halal industry, thereby establishing international best practices alongside mainstream food industry sectors. Information technology has been identified as a factor that can improve performance and efficiency and expand supply chain networks in the context of HSC management [19]. Additionally, the adoption of halal warehousing has been found to be significantly influenced by technological factors, emphasizing the importance of compatibility and perceived benefits [20].

There is a gap in the relationship between technology development and the supply chain of halal products. However, some of the literature has acknowledged the use of technology, such as digital tools in the halal supply chain [21] and sustainable halal supply chain using blockchain technology [22]. Therefore, we decided to conduct a systematic literature review on the topic.

Moreover, previous studies have emphasized the importance of technological advancements in ensuring halal integrity, certification, and auditing of food products, especially in the context of global supply chains (e.g., [23]). Additionally, the adoption of digital technology has been linked to the potential improvement of halal supply chain effectiveness, although it may impact efficiency [24]. The potential of halal logistics schemes as an innovation in the supply chain has been positively acknowledged, particularly in Southeast Asia [25]. However, previous research mainly focused on identifying technology adoption in the halal supply chain and discussed various technologies to enhance the halal supply chain. To our observation, there is a lack of comprehensive research on innovative digital technology in the halal supply chain and its impact on firm performance in both financial and non-financial aspects. Therefore, this study adds to the gap in the literature by system-

atically reviewing studies on innovative digital technology 4.0 in the halal supply chain and their relationship with firm performance.

Prior studies have attempted to review halal supply chain research but have been absent in explaining the innovative digital technologies in the halal supply chain and their connection with firm performance. For instance, an earlier bibliometric review study indicates a growing focus on halal supply chain research since 2016, predominantly led by Malaysian university researchers with a predominant emphasis on food-related studies [26]. However, those studies are still general and do not focus on specific topics such as innovative digital technology. Besides, previous review works identified five themes of the halal supply chain: control assurance, success factor criteria, distribution and production, halal supply chain support, and process engagement [27]. Those studies employed Google Scholar in the search processes, which could have limitations in terms of quality assessment. Another review work attempted to identify the role of the government in the promotion of halal logistics, including financial incentives, regulation, taxation, guidance, and encouragement, as well as education and provision of labor infrastructure [28]. Furthermore, on the food supply chain, five research clusters were documented using bibliometric analysis: food supply chain, halal supply chain, halal lifestyle, supply chain integration, and halal logistics [29]. Finally, previous researchers using a bibliometric approach documented five research topic clusters on studies of traceability systems in halal procurement: traceability, halal supply chain, food supply chain, halal logistics, and halal lifestyle [30].

More specifically, in a systematic literature review research, the halal supply chain presents both opportunities and challenges. The supply chain encompasses activities such as halal warehousing, transportation, sourcing, and logistics services [31]. The critical success factors of conventional supply chains can be applied to the halal supply chain, emphasizing the need for a comprehensive understanding of the factors contributing to its success [28]. Furthermore, the vulnerability of the halal supply chain to contamination is influenced by product characteristics and market requirements, necessitating control and assurance activities to maintain its integrity [2]. The implementation of halal logistics practices has been found to positively impact supply chain performance, highlighting the importance of readiness and stakeholder influence in ensuring successful implementation [32]. Additionally, the study of halal logistics constraints contributes to the growing body of literature in this area, enriching the understanding of halal logistics [32]. Previous research focuses more fundamentally on the halal supply chain. Our study is among the first to discuss the practice of innovative digital technology 4.0, which impacts firm performance in the context of halal supply chains from the existing academic literature.

In this study, two research questions are posed: (1) What innovative digital technology 4.0 is implemented in the halal supply chain, and (2) How does the implementation of innovative digital technology 4.0 impact firm performance? This study contributes to the literature and practical sides in the following ways. Theoretically, our study is among the first to explore innovative digital technology in the halal supply chain and firm performance. Thus, the study is expected to add to the knowledge by extending the halal supply chain study in relation to recent technological advancement and the company's performance. Practically, this study is expected to inform firms, either large or small-medium enterprises (SMEs), about the appropriate technologies that can be utilized to enhance their halal supply chain.

This paper is structured as follows. The next section outlines the methodology employed in this paper. Following that, the results and discussion of the study are presented. The final section offers conclusions and outlines future research directions.

2. Methods

This research employs the systematic literature review approach, which is useful in analyzing the advancement of a particular area of research [33,34]. The systematic literature review process, as [34] describe by [35], consists of five steps: (1) define the research question; (2) determine the required characteristics of primary studies; (3) retrieve a sample

of the potentially relevant literature ("baseline sample"); (4) Select the pertinent literature ("synthesis sample"); (5) reporting on the review; and (6) Report the results (Figure 1).

Step 1: Define the research question.

The questions formulated in this systematic review are the same as the research questions explained in the previous section, namely: (1) what innovative digital technology 4.0 is implemented in the halal supply chain?; and (2) how does the implementation of innovative digital technology 4.0 impact firm performance?

Step 2: Determine the required characteristics of primary studies

At this point, articles that align with the specified inclusion and exclusion criteria are segregated for reevaluation, while those not meeting the criteria are removed (refer to Figure 2). The study's inclusion and exclusion criteria are detailed in Table 1.

Table 1. Eligibility Criteria.

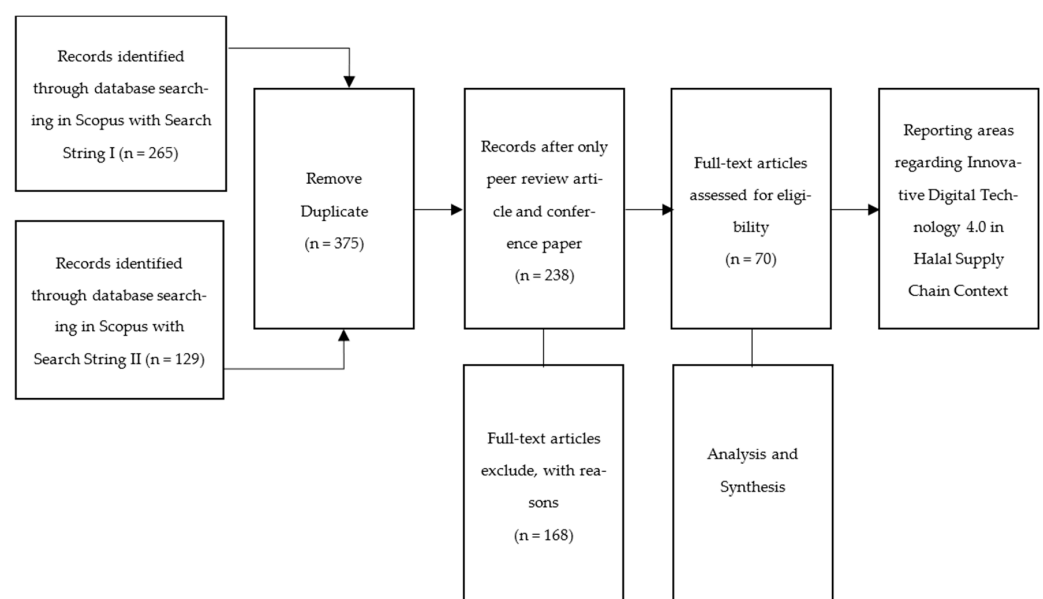| Items	Inclusion	Exclusion
Search Limitations	**Scopus**	**Database other than Scopus**
Keywords Search	Search string I: "Halal Supply Chain OR Halal Logistics" Search string II: ("Halal Supply Chain" OR "Halal Logistics" OR "Halal transport" OR "Halal procurement" OR "Halal product*" OR "Halal Delivery") AND ("optimization" OR "simulation" OR "AI" OR "machine learning" OR "blockchain" OR "Technology")	
Literature type	Peer review article, conference paper	Magazine articles, reports, non-indexed journals, Book Chapters, discontinued publications.
Abstract	Technology, digital, and innovation	Not included Technology, digital, and innovation
Language	English	Non-English
Timeline	2008–2023	Before 2000

Step 3: Retrieve a sample of the potentially relevant literature ("baseline sample").

At this step, methods involve choosing the search engine, database, and keywords for the literature search. The search is conducted on the Scopus academic database. Scopus is chosen because of its broad coverage and reliable quality assessment. Furthermore, the Scopus database is well-established and widely recognized in academic literature [36]. We conducted two searches using different search strings to retrieve articles that are relevant to this research. Firstly, the search string "Halal Supply Chain OR Halal Logistics" was applied in the title, abstract, and keywords, resulting in the identification of some articles from the selected source. Secondly, the search string II ("Halal Supply Chain" OR "Halal Logistics" OR "Halal transport" OR "Halal procurement" OR "Halal product*" OR "Halal Delivery") AND ("optimization" OR "simulation" OR "AI" OR "machine learning" OR "blockchain" OR "Technology") was employed in the title, abstract, and keywords. This search also yielded articles from the selected source. The authors excluded certain identified publications if they did not meet the predetermined criteria and did not include conference proceedings in this analysis. The sign asterisk (*) was used in the keyword "halal product" to include other related keywords, such as "halal products" (plural) and "halal production".

Three hundred ninety-four articles were gathered using specified search parameters. We removed duplicate articles and ended up with 375 unique articles. Of these, 238 articles were identified as peer-reviewed articles or conference papers. During the screening process, by reading the full text of the articles, we focused on those that discussed technology or digital as the main keywords. Articles not centered around technology or digital aspects were excluded from the analysis and synthesis. After reading the full text of the articles, only 70 articles were selected.

Step 1 : Define research question
At this stage define the objective of the literature review

Step 2 : Determine required characteristics of primary studies
Develop criteria for determining publications

Step 3 : Retrieve sample of potentially relevant literature ("baseline sample")
Identify literature through structured and rigorous searches

Step 4 : Select pertinent literature ("synthesis sample")
Systematically choose relevant literature based on theoretical principles, following specified inclusion and exclusion criteria.

Step 5 : Synthesize literature
Create two data extraction frameworks aligned with aspects of the initial theoretical framework.

Step 6 : Report the results
Explain refined theoretical framework and compare with initial theoretical

Figure 1. SLR roadmap. Source: Adapted from [35].

Records identified through database searching in Scopus with Search String I (n = 265)

Records identified through database searching in Scopus with Search String II (n = 129)

Remove Duplicate (n = 375)

Records after only peer review article and conference paper (n = 238)

Full-text articles assessed for eligibility (n = 70)

Reporting areas regarding Innovative Digital Technology 4.0 in Halal Supply Chain Context

Full-text articles exclude, with reasons (n = 168)

Analysis and Synthesis

Figure 2. A step-by-step procedure for choosing, analyzing, and reporting articles. Source: Adapted from [37].

Step 4: Select pertinent literature (synthesis sample").

The analysis phase attempts to characterize an individual's study, which is then split into specific components, and the relationships between these components are established [38]. Following the analytical step, a synthesis is carried out to connect the elements discovered in the various studies.

The analysis process starts by identifying the use of digital technology in halal supply chain management, which then leads to the identification of the implementation of digital technology practices in the halal value chain and its impact on firm performance. Finding research gaps to inform future research agendas is the main objective.

Step 5: Synthesize literature.

In this stage, we extracted data from the articles that had been selected based on the predetermined criteria. We then integrated the data to synthesize the theoretical framework. In this study, we aim to determine what technologies are used in the halal supply chain and how the use of these technologies can impact company performance.

Step 6: Report the results.

Elaborate on the enhanced theoretical framework and contrast it with the original theoretical assumptions [35]. This study examines the development of research on the use of digital technology and its impact on firm performance in the context of halal supply chains.

3. Results

In this research, we generally review research on the application of innovative digital technology 4.0 in the context of the halal supply chain, which has evolved from 2008 to the present. The highest number of articles on the topic of innovative digital technology 4.0 is in 2023, reaching 17 articles. It reflects that research interest in applying digital innovation Technology 4.0 in the halal supply chain is still very high. A total of 70 articles published between 2008 and 2023 fulfill the systematic criteria of the literature review (Figure 3).
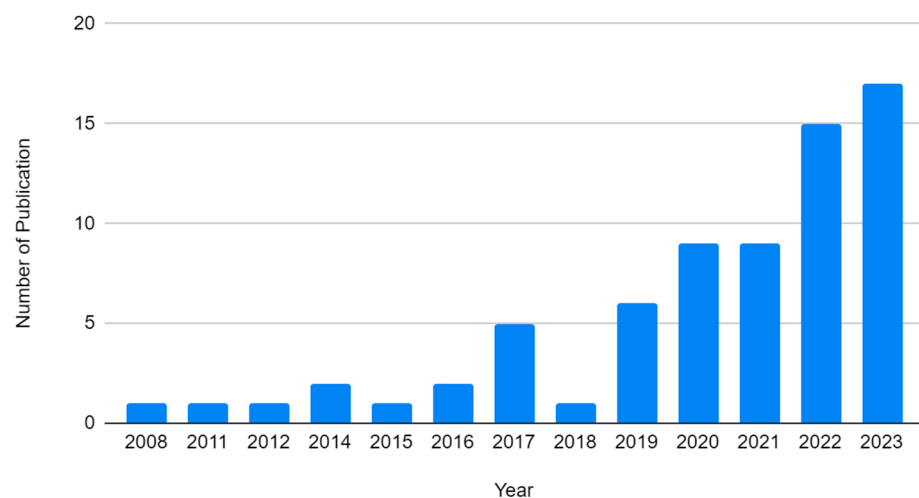
Figure 3. Number of Publication by Year.

Based on the 70 articles analyzed, the most frequently used innovative digital technology 4.0 in the context of the halal supply chain is Blockchain Technology, accounting for 31% of the innovative digital technology that has been identified Halal traceability systems (RFID, IoT) (11.1%) is the second most common, followed by, Halal financial technology accounting for 6.9% of the sample studied (Figure 4).
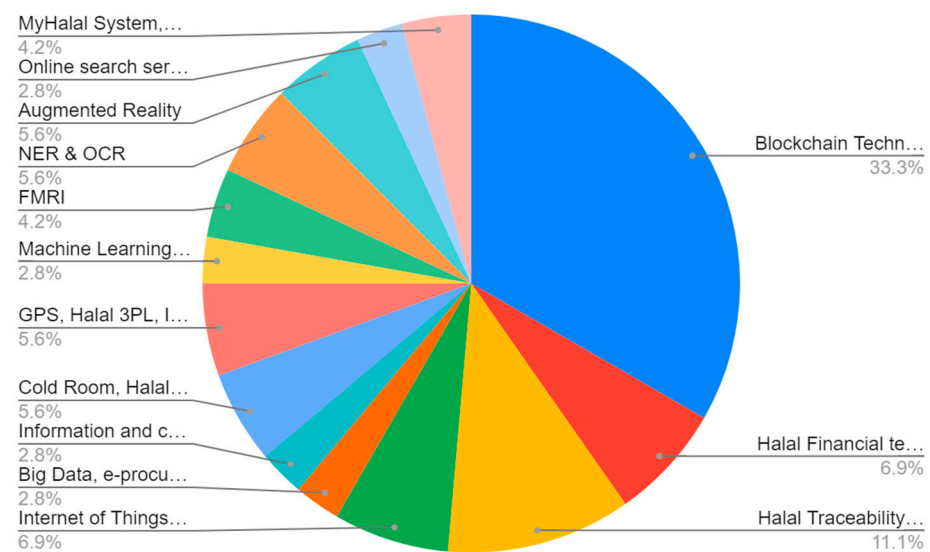
Figure 4. The use of innovative digital technology frequency.

4. Discussion

We categorize innovative digital technology into four primary functions within the halal supply chain (Figure 5): halal manufacturing, halal procurement, distribution, and logistics [39] (Technology details of each of the four main functions of the halal supply chain can be seen in Appendix A).
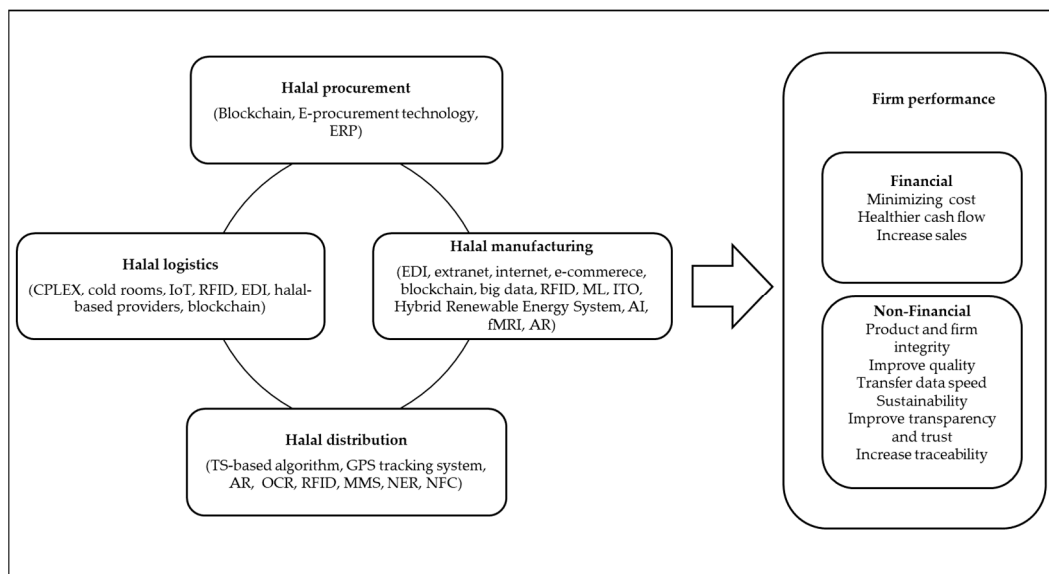
Figure 5. Digital technology 4.0 in the halal supply chain.

Blockchain technology is generally utilized across all primary functions within the supply chain. To elaborate on Figure 5, we introduce Table 2, offering more detailed insights into comparing each technology used in the firm's key activities. Additionally, our focus is on delivering a comprehensive overview of the financial and non-financial consequences the company may experience upon implementing these technological practices in its operations.

Table 2. Technology in Halal Supply Chain.

Authors			Halal Supply Chain				Firm Performance	
		Halal Procurement	Halal Manufacturing	Halal Distribution	Halal Logistics	Financial		Non-Financial
[24]	2020	x	EDI, Extranet, Internet, and electronic commerce	x	x	x		Technology can improve the effectiveness of supply chain processes in family halal food businesses.
[40]	2023	x	x	TS-based algorithm	x	Minimizing transportation costs		Ensure the integrity of Halal products
[41]	2019	x	x	x	CPLEX and hybrid genetic algorithm	Minimizing cost		Improve the efficiency of locating farms, butcheries, and food plants
[42]	2023	x	Shariah Financial Technology (FinTech)	x	x	Enhance business strategy by minimizing costs		The developed HSCMT prototype increases the effectiveness of Halal Supply Chain Management for Malaysia Halal SME Owners (MHSO) with an average usability score of 83.67.
[43]	2023	Blockchain Technology	x	x	x	Increase operational costs		Improved product quality due to well-managed traceability management
[44]	2023	x	x	x	Pharmaniaga Lifescience (Cold rooms)	x		Increase efficient halal document checking and verification process
[45]	2022	x	Blockchain Technology	x	x	The use of Blockchain with the Avalanche platform is more cost-effective than the Ethereum network		Blockchain-Based Traceability System to Support the Indonesian Halal Supply Chain Ecosystem
[46]	2021	x	Permissioned Blockchain (Hyperledger Fabric)	x	x	x		Permissioned Blockchain is useful for the Halal Supply Chain not just because it can secure transactions from some of the halal issues (trust, transparency, and information disclosure) but also because the transaction speed and rate to transfer data are very effective.

Table 2. *Cont.*

Authors		Halal Supply Chain				Firm Performance	
		Halal Procurement	Halal Manufacturing	Halal Distribution	Halal Logistics	Financial	Non-Financial
[47]	2021	x	x	x	Internet of Things (IoT), RFID, and EDI	x	The use of technology in halal logistics can improve the quality of information, the quality of personnel contact, order accuracy, order conditions, order discrepancies, and order expenditure amount.
[48]	2022	x	Big Data (Data-driven)	x	x	x	Improve the firm's ability to be more sustainable in the halal food chain process
[49]	2022	x	Blockchain Technology	x	x	x	Improve the halal food supply chain's traceability from farm to fork.
[50]	2020	e-procurement technology	x	x	x	x	The use of technology can improve performance in order to speed halal traceability. However, the use of technology needs to be balanced with the ability of employees to use this technology.
[51]	2020	x	Blockchain Technology	x	x	Investing in blockchain technology requires a lot of resources, especially in terms of costs.	Can improve halal traceability
[52]	2021	x	(RFID) with Hazard Analysis Critical Control Point	x	x	Reduce the cost of product removal from the market	Preventing the occurrence of product recalls, especially in terms of halal assurance, will lead to the level of customer trust and confidence in the integrity of the halal industry
[42]	2023	x	Shariah Fintech	x	x	This fintech can bridge international transactions.	It can assist firms in tracking financial activities.

Table 2. *Cont.*

Authors		Halal Supply Chain				Firm Performance	
		Halal Procurement	Halal Manufacturing	Halal Distribution	Halal Logistics	Financial	Non-Financial
[53]	2022	x	x	x	(ICT)-Digitally-enable community	x	Improve the efficiency with which halal logistics are conducted, offer improved logistical organization, and boost halal performance.
[54]	2022	x	Blockchain Technology	x	x	x	Ensuring transparency and security related to Halal Fashion Traceability
[55]	2023	x	Blockchain Technology	x	x	Benefits from the tracking system made possible by blockchain technology include evidence of the transparent flow of finances, information, and goods from producer to customer.	Supporting blockchain technology's accessibility can improve traceability and transparency, connecting upstream and downstream flows that influence improvements in the efficiency of the Halal supply chain's performance.
[56]	2016	x	x	GPS tracking system	x	x	Assist the firm in tracking and tracing products and vehicles carrying halal goods during the shipping process so that it is more effective and verification can be done automatically.
[57]	2023	x	Sharia Financial Technology	x	x	x	Increase sustainability of MSMEs in Malaysia and Indonesia by 90% through waqf participation
[58]	2023	x	Blockchain Technology	x	x	x	More transparent transaction processes through decentralized protocols can increase the value of innovation in management decision-making in each operation process.

Table 2. *Cont.*

Authors		Halal Supply Chain				Firm Performance	
		Halal Procurement	**Halal Manufacturing**	**Halal Distribution**	**Halal Logistics**	**Financial**	**Non-Financial**
[59]	2023	x	Machine Learning	x	x	x	Adapting this technology will create a new offer to existing customers to be more loyal, and data collection will then be recorded, which ends in deep learning customer engagement always to provide an appropriate and satisfying service.
[60]	2023	x	x	x	Product ID and RFID	x	The usage of Halal traceability technology in Halal logistics can significantly improve the performance of logistics service providers and enhance the market recognition of their Halal logistics brand.
[61]	2022	x	Halal traceability system	x	x	"The use of a halal traceability system would assist our firm in reducing the operating cost".	The adoption of a halal traceability system can enhance SME business and improve the integrity of the halal industry.
[62]	2020	x	Financial Technology	x	x	x	Increase synergy in the halal industry ecosystem by emphasizing the role of each institution in minimizing the problems related to the halal industry
[63]	2020	x	x	x	Halal-based third-party logistics (3PL) providers	x	Halal-based 3PL providers with high and medium resource capabilities achieve greater customer service innovation and cost advantages significantly
[64]	2015	x	Information Technology Outsourcing (ITO)	x	x	Lower labor specialization costs while simultaneously raising cash flow and the financial performance index.	Provides detailed factors in the relationship between IT Outsourcing and the company.

Table 2. *Cont.*

Authors		Halal Supply Chain				Firm Performance	
		Halal Procurement	**Halal Manufacturing**	**Halal Distribution**	**Halal Logistics**	**Financial**	**Non-Financial**
[65]	2021	x	Blockchain Technology	x	x	x	It can help companies identify the authenticity of halal certification processes to increase trust and ensure the authenticity of halal logos.
[66]	2022	x	Halal Transportation System	x	x	Can save transportation costs incurred	The benefits of using the Halal transportation system among Halal food manufacturers are easing the doubts about Halal quality and increasing the image of the products.
[20]	2022	x	Halal Warehousing System	x	x	x	The firm can measure products/goods that are aligned with Halal specifications, value systems, and job responsibilities.
[1]	2021	x	Blockchain Technology, IoT, and RFID	x	x	x	Implementing technology-driven solutions can help in reducing risks associated with product adulteration, counterfeiting, and non-compliance with halal requirements.
[67]	2020	x	Displacement Loop mtDNA	x	x	x	Facilitate halal forensic investigations in determining the halalness of critical raw materials (animal)
[68]	2020	x	functional magnetic resonance imaging (fMRI).	x	x	x	Knowing consumer interest in buying halal products that have a halal logo
[69]	2021	x	x	x	Blockchain technology	x	Improve efficiency in traceability during the logistics process so as to minimize product contaminations
[70]	2019	x	functional magnetic resonance imaging (fMRI).	x	x	x	Knowing consumer desires in choosing halal products
[71]	2022	x	x	NER and OCR	x	x	Ensuring products received by consumers are in accordance with halal standards

Table 2. *Cont.*

Authors			Halal Supply Chain				Firm Performance	
		Halal Procurement	Halal Manufacturing	Halal Distribution	Halal Logistics	Financial	Non-Financial	
[72]	2022	x	Augmented Reality	x	x	The cost incurred to adopt this technology is quite expensive	Increase consumers' awareness of buying halal cosmetics because it gives them experience before buying the product.
[73]	2022	x	functional magnetic resonance imaging (fMRI).	x	x	x	Facilitate marketing managers in making halal product advertisements by paying attention to the ethical and emotional aspects of customers.
[74]	2020	x	Sharia Fintech	x	x	x	Facilitate the tracking of transactions that comply with Sharia principles.
[75]	2021	x	Blockchain Technology	x	x	x	Ensuring the halal traceability of a product, thus increasing consumer interest in buying the product
[76]	2023	x	Blockchain Technology	x	x	Can reduce the expenses associated with manual halal traceability processes.	Improve transparency and trust in the supply chain
[77]	2021	x	Blockchain Technology	x	x	Minimize lost costs	Improve integration and accountability of Halal Assurance System stakeholder data activities. Can further increase consumer confidence and awareness of the value of halal products
[78]	2022	x	Blockchain Technology	x	x	x	Improved transparency, traceability, and timely decision-making
[79]	2022	x	Blockchain Technology	x	x	Increase product sales	Increase the certainty that products have been processed in accordance with applicable halal standards.

Table 2. *Cont.*

Authors		Halal Supply Chain				Firm Performance	
		Halal Procurement	Halal Manufacturing	Halal Distribution	Halal Logistics	Financial	Non-Financial
[80]	2023	x	blockchain, Internet of Things (IoT), Artificial Intelligence (AI)	x	x	x	Enhanced monitoring and assurance of adherence to diverse standards and sustainability across the supply chain.
[81]	2022	x	Blockchain Technology	x	x	The cost of implementing blockchain technology is quite high	Ensuring transparency in documentation involves effectively recording information and transactions. The system has demonstrated its security and transparency, as all involved parties have public access to transaction details.
[82]	2019	x	Online search service	x	x	x	Improving the effectiveness of halal product status search
[83]	2023	x	Halal dengue vaccine technology	x	x	Affordable price	Improving prevention of dengue fever outbreaks
[84]	2020	x	Internet of things	x	x	High costs	The implementation of IoT has undoubtedly established a reliable platform for the supply chain of halal agro-food SMEs.
[85]	2019	x	x	Blockchain Technology	x	x	Improve traceability of halal documents
[86]	2019	x	digital object architecture (DOA) & RFID	x	x	x	The system provides effective technical guidelines for companies to monitor the entire product lifecycle using the Internet of Things.
[87]	2022	x	Blockchain technology	x	x	x	Improve the integrity of the halal supply chain
[88]	2023	x	Machine Learning	x	x	x	Improve the efficiency of checking the difference between halal products and non-halal products.

Table 2. *Cont.*

Authors		Halal Supply Chain				Firm Performance	
		Halal Procurement	Halal Manufacturing	Halal Distribution	Halal Logistics	Financial	Non-Financial
[89]	2023	x	Blockchain technology	x	x	x	Improving transparency in halal supply chain and assurance pathways
[90]	2019	x	Blockchain technology	x	x	x	Improving transparency and assurance of halal compliance
[91]	2021	x	Blockchain technology	x	x	Minimize tracking costs	Tracking speed is up to 10 times faster than conventional methods, leading to minimized losses through more targeted issue resolution.
[92]	2023	x	x	Blockchain, RFID, QR Code	x	x	Increase consumer trust to buy halal products
[93]	2023	Blockchain Technology and ERP	x	x	x	Reduce operational cost	Through effective management of halal product procurement, companies can guarantee the delivery of products with halal assurance to consumers.
[94]	2017	x	x	OCR and Augmented Reality	x	x	Improve efficiency in checking the halal status of products
[95]	2016	x	x	RFID	x	x	The verification of the product's Halal status becomes straightforward, as each tag embedded in food packages is assigned a unique identification number.
[96]	2008	x	x	MMS camera phone-based	x	Production cost savings	Effective way method to accelerate the Halal verification procedure.
[97]	2012	x	x	MyHalal system	x	x	Improve verification of halal product status in real-time
[98]	2017	x	x	OCR and Augmented Reality	x	x	Enhance the efficiency of verifying the halal status of products.
[99]	2017	x	x	OCR and Web Service	x	x	Improve the effectiveness of confirming the halal status of products.

Table 2. *Cont.*

Authors		Halal Supply Chain				Firm Performance	
		Halal Procurement	**Halal Manufacturing**	**Halal Distribution**	**Halal Logistics**	**Financial**	**Non-Financial**
[100]	2014	x	x	x	Information Communication Technology (ICT)-RFID	x	Improve the effectiveness of monitoring halal transportation
[101]	2017	x	x	Augmented Reality	x	x	Enhance the efficiency of verifying the halal status of products.
[102]	2017	x	RFID and NFC	x	x	x	NFC and RFID mobile shopping technologies streamline the validation of halal status, allowing customers to do so effortlessly through their personal smartphones.
[103]	2018	x	Online Traceability	x	x	x	Improve company reputation
[104]	2014	x	Hybrid Renewable Energy System	x	x	x	Improving the sustainability of environmentally friendly businesses
[105]	2011	x	RFID	x	x	x	Improving the integrity of halal products

4.1. Halal Procurement

Halal procurement involves obtaining goods and resources in compliance with Islamic law, ensuring the halal product's integrity throughout the supply chain [2]. It includes sourcing halal-compliant inputs, by-products, and resources, extending beyond raw materials and production to encompass the entire supply chain, including distribution and logistics [2,106,107]. The concept has evolved due to growing awareness, emphasizing the need for organizations to establish a robust procurement function aligned with Islamic values [108]. A halal procurement maturity model can facilitate this development. The integrity of halal products is upheld through various supply chain activities, highlighting the importance of a holistic approach to ensure halal integrity at the point of consumption. It can be concluded that in the halal food supply chain industry, supplier flexibility plays an important role that can affect other criteria, such as cost and footprint. For instance, a hybrid approach to model halal supplier flexibility criteria emphasizes the influence of Blockchain Technology in enhancing traceability but, on the other hand, will increase operational costs [43]. Prior research also investigated the influence of service quality from halal suppliers and the preparedness of staff to embrace E-procurement technology on the performance of halal logistics [50]. It underscores the pivotal role of technology in improving order speed and traceability, with a cautionary note on the necessity to balance technological adoption with employees' proficiency.

Moreover, integrating blockchain and ERP can enhance corporate governance, leading to improved company performance in the long run and reducing operational costs. Through effective management of halal product procurement, companies can guarantee the delivery of products to consumers with halal assurance [93]. Overall, these studies contribute valuable insights into the dynamic landscape of halal procurement, highlighting the importance of technological advancements and flexibility criteria in shaping both financial and non-financial aspects of firm performance in the halal supply chain.

4.2. Halal Manufacturing

Halal manufacturing refers to the production of goods under Islamic Shariah law, ensuring that the ingredients, manufacturing processes, and techniques used comply with the standards set by Islamic guidelines [109]. It includes various aspects such as certification, transportation, and warehousing [20,66,110].

Furthermore, adopting halal practices in manufacturing can lead to improved business performance and expansion opportunities, particularly in countries with a significant Muslim consumer base [111–113]. The adoption of innovative digital technology in halal manufacturing has become increasingly significant. Various studies emphasize the impact of technology in improving the efficiency and competitiveness of halal supply chains [51,55]. Technologies like the Internet, Extranet, EDI, and electronic commerce can potentially enhance the efficiency of the family supply chain in the halal food business [24].

However, the financial commitment can challenge family business proprietors, particularly in the halal food sector. The prototype of Halal Supply Chain Management Transactions (HSCMT) with halal financial technology (FinTech) can improve the effectiveness of halal supply chain management for Malaysian Halal SME Owners (MHSO) [42]. Meanwhile, big data technology can improve companies' ability to become more sustainable in the halal food chain process [48]. On the other hand, a study by [51] suggests that while blockchain technology can improve the halal footprint, the investment required can be significant.

Furthermore, digitization and financial technology (FinTech) through waqf funds can increase the sustainability of MSMEs in Malaysia and Indonesia by 90%, highlighting the critical role of technology in increasing waqf participation and the performance of micro and small enterprises [57]. Also, blockchain provides an opportunity to promote value innovation in the halal industry, potentially increasing the transparency of transactions and value innovation in management decision-making [58]. It was highlighted that the development of synergies between Islamic banks and Muslim-friendly tourism involves

technologies such as Machine Learning and Digital Innovation Services, which can create new offers and increase customer loyalty [59]. The study of the halal footprint system shows that the application of halal footprint technology can help reduce operational costs, improve the business performance of MSMEs, and improve the integrity of the halal industry [61]. In the context of fintech, building an integrated Islamic financial ecosystem involves financial technology (fintech) to increase synergy in the halal industry [62]. In addition, highlighted that Information Technology Outsourcing (ITO) can help MSMEs in Malaysia accelerate e-Business adoption, reduce labor specialization costs, and increase cash flow [64]. Pertaining to quality-life improvement through technology, blockchain was proposed to improve the economy, education, and health industries [65]. Technology adoption in the halal supply chain, particularly in transportation, is essential to save costs and improve the image of halal products [66].

Finally, technology in halal warehousing can help companies measure products that comply with halal specifications and system values [20]. Overall, technologies such as blockchain, FinTech, Big Data, and RFID have a positive impact on the effectiveness and transparency of the halal supply chain. However, significant financial and investment challenges remain a concern for companies adopting them [24,42,48,51]. Furthermore, to enhance their success prospects in Muslim markets, marketing managers of multinational companies should employ advertising messages emphasizing the ethical aspects of their products and utilizing cognitive appeals rather than emotional ones using functional magnetic resonance imaging (fMRI) technology [68,70,73]. On the other hand, using a hybrid renewable energy system can minimize the excess energy that occurs during the production process and will improve the sustainability of environmentally friendly businesses [104].

4.3. Halal Distribution

The Halal distribution network plays a crucial role in preserving the halal status of products and implementing protective and preventive measures to guarantee the continuity of halal status from production to consumer delivery [23]. Several technologies have been used in halal distribution to improve company performance. For example, the Traceability system-based algorithm (TS-Based Algorithm) is used to optimize the distribution of halal products [67]. The use of this algorithm has the potential to make a significant contribution to company performance by reducing transportation costs while ensuring the sustainability and authenticity of halal products. Meanwhile, GPS tracking technology (Halaltracer Technology) monitors and tracks cargo and vehicles carrying halal commodities during the shipping process [56]. This tracking technology can positively contribute to company performance by increasing the effectiveness of tracking halal products and vehicles during the shipping process, which automatically facilitates more efficient verification. The food sector focuses on applying named-entity recognition (NER) and optical character recognition (OCR) to identify halal food ingredients in Indonesia. This will increase firm performance, such as Ensuring products received by consumers are under halal standards [71].

Additionally, the use of blockchain technology will Improve the traceability of halal documents [85]. It is in line with research on the use of Blockchain, RFID, and QR Codes, which can enhance consumer trust in halal products [92]. Using OCR, RFID, and Augmented Reality will Improve efficiency in checking the halal status of products [95,98,99]. However, the financial impact of using the technology is not explicitly known.

4.4. Halal Logistics

Halal logistics refers to the implementation of Shariah-compliant processes in handling and distributing goods throughout the entire supply chain [114]. This definition underscores the adherence to Shariah principles in logistics operations. The concept of Halal logistics is indeed gaining significance within the supply chain management domain [115]. Key elements essential for the successful adoption and execution of Halal logistics within the Halal supply chain encompass the establishment of suitable guidelines, standards, and

codes for the training of Halal logisticians [116]. Additionally, the involvement of Halal logistics in the industry is becoming more complex due to the integration of components such as Shariah governance, halal assurance, and logistics [117]. Moreover, the readiness of consumers to pay for Halal products is associated with the necessity for Halal logistics certification [48]. Halal logistics encompasses a range of activities and processes, including transportation, warehousing, terminal operations, and traceability throughout the supply chain [28,118].

There are variations in the use of technology in halal logistics. For example, Ref. [41] highlighted the importance of separating halal and haram products and considering the chain effect of haram facilities on the entire halal food logistics network by using CPLEX technology and hybrid genetic algorithms for the optimization of the location and allocation of halal logistics networks, including farms, slaughterhouses, and food factories that follow Islamic food regulations. While there are indications of increasing costs in the development of halal logistics networks, this does not mean that every cost element continues to increase. This technology can improve efficiency in locating farms, slaughterhouses, and food factories.

Furthermore, the importance of technology readiness in improving customer satisfaction and organizational operations in the halal meat industry was highlighted [47]. Internet of Things (IoT), RFID, and EDI were found to improve information quality, personnel contact, order accuracy, order conditions, order discrepancies, and order spending amounts. In line with this, halal logistics brand building through halal tracking technology and training use Halal Tracking Technology (Product ID and RFID) to improve the performance of logistics service providers and increase their halal logistics brand recognition in a competitive market [60]. The specific use of technology in the ASEAN region focuses on developing a digital society and its impact on the region's potential to become a global leader in halal logistics [53]. In that study, information and communication technology (ICT) were used to foster a digitally connected society.

Furthermore, using ICT (RFID) can help companies monitor their transportation [100]. The impact includes increased halal logistics efficiency, better logistics organization, and improved halal performance. On the other hand, in the cosmetics industry, the use of Pharmaniaga Lifescience technology can improve the efficiency of the inspection process and the verification of halal documents to facilitate the flow of products in the warehouse [44]. In addition to focusing on technological development in halal logistics, it shows that the emerging resource capabilities of halal logistics services significantly impact customer service innovation and cost advantages [63]. Halal-based third-party logistics service providers should focus on developing their resource capabilities to improve competitiveness in the dynamic halal market.

The technologies in use today prove that the challenges and opportunities associated with emerging technologies in conventional supply chains also apply to halal supply chains. The initial disillusionment with emerging supply chain technologies, as discussed by [119], can be paralleled with the challenges faced in implementing technology-based solutions in halal supply chains. Similarly, the insights regarding digital technologies for real-time data collection and decision support systems can be applied to the halal supply chain, where ensuring the integrity of halal products from source to consumption is critical [120]. In addition, game-based workshops for knowledge transfer within the timber supply chain can be adapted to the halal supply chain [121]. This adaptation aims to enhance comprehension, ensure compliance with halal standards among supply chain stakeholders, and provide decision support for contingency planning and bottleneck analysis in halal supply chain management [121,122]. Nevertheless, certain technologies, such as digital twins and various simulation methods like discrete event simulation, agent-based simulation, and system dynamics, which were not addressed in this research, have shown promise in enhancing decision-making processes within supply chains [123,124]. These technologies could also be effectively employed within halal supply chains to aid management decision-making.

5. Conclusions

In the realm of halal supply chain management, information technology has been identified as a factor capable of improving overall performance efficiency and expanding supply chain networks. Moreover, the adoption of halal storage is significantly influenced by technical variables, emphasizing the importance of compatibility and perceived advantages. Previous studies have underscored the crucial role of technological advancements in ensuring the integrity, certification, and auditability of halal food items throughout the entire supply chain, especially in the context of global supply networks. While digital technology may impact efficiency, its utilization is linked to the potential improvement of the effectiveness of the halal supply chain.

The implications of these findings extend beyond the immediate context of halal supply chain management, offering valuable insights for businesses, especially small and medium-sized enterprises (SMEs). The first is related to technology selection for SMEs. SMEs facing rising costs in establishing halal logistics networks can benefit from insights into the right technologies. This study suggests that SMEs should consider technology's compatibility and perceived benefits to enhance their halal supply chains. The second is related to flexibility and supplier dynamics. To recognize supplier flexibility's crucial role in influencing factors like footprint and cost, businesses should strategically leverage technology to enhance their supply chain agility. The findings also highlight the potential trade-offs associated with adopting blockchain technology, emphasizing the importance of a balanced approach. The third is concerned with halal production for market expansion. Companies operating in regions with sizable Muslim consumer bases are encouraged to invest in halal production procedures. It aligns with Islamic standards and has the potential to boost corporate performance and facilitate expansion in these markets.

We acknowledge that this paper has several limitations. First, the research is limited to the halal supply chain, which suggests that the applications of the technologies identified may not be extendable to other fields. Any adaptation for use in different fields will require adjustments, as these technologies are designed to ensure compliance with Islamic standards, which is the focus of the halal supply chain. Second, the use of a systematic literature review method in this study prevents the identification of practices and challenges associated with implementing innovative digital technology 4.0 by the firm. Third, we exclusively rely on the Scopus database for our research, potentially resulting in the omission of pertinent articles that fall outside the scope of Scopus and, consequently, are not subject to analysis in this study. Fourth, the criteria we used to select the articles analyzed only focused on using digital 4.0 innovative technology in the halal supply chain, which may indicate bias and inconsistency.

Future research in innovative digital technology 4.0 within the context of the halal supply chain could focus on three key aspects. First, future studies may address holistic technology integration by delving into the development and implementation of technology in various stages of the halal supply chain, from procurement to distribution. Understanding how technology enhances efficiency, transparency, and compliance with halal standards at each stage will contribute to a more comprehensive perspective. Second, conducting a quantitative analysis to measure the specific financial performance of companies adopting digital technologies is essential. Employing methods such as cost-benefit analysis will provide insights into the economic impact of technology adoption in the halal supply chain. Third, investigating the feasibility and importance of technology adoption for Small and Medium Enterprises (SMEs) in the halal sector is critical for future research. Understanding whether blockchain, RFID, GPS tracking, and fintech are vital for SMEs to remain competitive and adhere to halal principles will inform strategic decision-making for businesses of all sizes. Fourth, future research can adapt digital twins and simulation methods, such as discrete event simulation, agent-based simulation, and system dynamics, to be applied to halal supply chain management.

This study not only contributes to the understanding of the halal supply chain but also opens avenues for further exploration into the broader implications of technology adoption

in diverse industries and the specific challenges and opportunities that SMEs frequently encounter. The unique focus on Islamic standards and halal compliance makes this research a valuable resource for businesses seeking to navigate the intersection of technology and effective supply chain management.

Data Availability Statement: Data supporting this study are included within the article and the Appendix A.

Appendix A

Table A1. Technology in Halal Distribution.

Authors	Year	Findings	Technology in Halal Distribution	Firm Performance	
				Financial	Non-Financial
[40]	2023	The experiments conducted on numerical data and life-sized instances validate the proposed model and algorithm for optimizing halal product distribution while minimizing transportation costs and ensuring the integrity of halal products	TS-based algorithm	Minimizing transportation costs	Ensure the integrity of Halal products
[56]	2016	This article describes the Halal tracer technology, which enables tracking and tracing of cargo and vehicles carrying Halal commodities throughout the shipping process.	GPS tracking system (Halaltracer Technology)	x	Assist the firm in tracking and tracing products and vehicles carrying halal goods during the shipping process so that it is more effective and verification can be done automatically.
[71]	2022	focuses on the application of named-entity recognition (NER) and optical character recognition (OCR) for identifying halal food ingredients in Indonesia	NER and OCR	x	Ensuring products received by consumers are in accordance with halal standards
[85]	2019	Efficient segregation relies on effective communication, where the term 'halal supply chain' is encoded in shipping documents, on cargo labels, and within the ICT system.	Blockchain Technology	x	Improve traceability of halal documents

Table A1. *Cont.*

Authors	Year	Findings	Technology in Halal Distribution	Firm Performance	
				Financial	Non-Financial
[92]	2023	Special tags are used to trace food products from the farm to the consumer and back, enabling the tracing of halal food items from consumer to producer, thereby reducing the risk of contamination	Blockchain, RFID, QR Code	x	Increase consumer trust to buy halal products
[94]	2017	The augmented reality technology scans the product's brand to showcase its halal status. The results indicate user satisfaction with the application, deeming it useful and user-friendly.	OCR and Augmented Reality	x	Improve efficiency in checking the halal status of products
[95]	2016	Enable consumers to efficiently verify the Halal status of products wirelessly.	RFID	x	The verification of the product's Halal status becomes straightforward, as each tag embedded in food packages is assigned a unique identification number.
[96]	2008	Camera phone-based MMS applications offer a cost-effective and efficient means to expedite the Halal verification process compared to entering text via SMS.	MMS camera phone-based	Production cost savings	Effective way method to accelerate the Halal verification procedure.
[97]	2012	The system can promptly verify and recognize product information, confirming their Halal status in real time.	MyHalal system	x	Improve verification of halal product status in real-time
[98]	2017	The augmented reality technology scans the brand of the product to display its halal status.	OCR and Augmented Reality	x	Enhance the efficiency of verifying the halal status of products.
[99]	2017	The test results indicate that the developed application can identify Halal products based on the labeled information.	OCR and Web Service	x	Improve the effectiveness of confirming the halal status of products.
[101]	2017	The use of augmented reality can detect halal product status	Augmented Reality	x	Enhance the efficiency of verifying the halal status of products.

Table A2. Technology in Halal Manufacturing.

Authors	Year	Findings	Technology in Halal Manufacturing	Firm Performance	
				Financial	**Non-Financial**
[24]	2020	The use of technology in the family halal food business can improve the effectiveness of their supply chain, leading to improved product quality and meeting customers' requirements	EDI, Extranet, Internet, and electronic commerce	Applying technology in the company's supply chain requires an investment, which requires huge amounts of funds for the family business owners, especially in the halal food industry.	Technology can improve the effectiveness of supply chain processes in family halal food businesses. However, it does not necessarily lead to increased efficiency.
[42]	2023	The Halal Supply Chain Management Transactions (HSCMT) prototype includes a payment gateway that can be embedded into a Halal SME owners' e-commerce site, creating a holistic Halal Financial technology (FinTech) transaction permissibility dashboard.	Halal Financial Technology (FinTech)	Enhance business strategy by minimizing costs	The developed HSCMT prototype increases the effectiveness of Halal Supply Chain Management for Malaysia Halal SME Owners (MHSO) with an average usability score of 83.67.
[45]	2022	The model Blockchain-Based Traceability system can be enhanced to be a national standard tool to develop the economy towards a sustainable supply chain.	Blockchain Technology	The use of Blockchain with the Avalanche platform is more cost-effective than the Ethereum network	Blockchain-Based Traceability System to Support the Indonesian Halal Supply Chain Ecosystem
[46]	2021	Blockchain technology has the potential to improve the Halal Supply Chain by enhancing trust, transparency, and information disclosure between supply chain participants. Permissioned Blockchain, such as Hyperledger Fabric, is suitable for the Halal Supply Chain as it ensures transaction security, speed, and effective data transfer.	Permissioned Blockchain (Hyperledger Fabric)	x	Permissioned Blockchain is useful for the Halal Supply Chain not just because it can secure transactions from some of the halal issues (trust, transparency, and information disclosure) but also because the transaction speed and rate to transfer data are very effective

Table A2. *Cont.*

Authors	Year	Findings	Technology in Halal Manufacturing	Firm Performance	
				Financial	Non-Financial
[48]	2022	The results show that the most significant factors for the non-Halal sustainable food supply chain in dictators are food consumption, food safety, food security, resilience, and food waste management. The most crucial indicators of a Halal sustainable food supply chain consist of Halal certification, Halal supply chain trust, Islamic values, and Halal food safety.	Big Data (Data-driven)	x	Improve the firm's ability to be more sustainable in the halal food chain process
[49]	2022	The technology with the smart contract is proposed with inputs from three Blockchain software providers with the aim to create a conceptual framework that integrates both Halal processes and technologies to improve traceability of Halal food supply chain from farm to fork	Blockchain Technology	x	Improve the halal food supply chain's traceability from farm to fork.
[51]	2020	This study provides an integrated model that explains 73.19% of the variance in intention to participate in blockchain-based Halal traceability systems.	Blockchain Technology	Investing in blockchain technology requires a lot of resources, especially in terms of costs.	Can improve halal traceability
[52]	2021	The article outlines the elements of the halal supply chain, including human resources, processes, environment, accreditations, logistics, and traceability. The objective is to enhance productivity and quality for food manufacturers involved in the production of halal products.	Radio Frequency Identification Device (RFID) with Hazard Analysis Critical Control Point	Reduce the cost of product removal from the market	Preventing the occurrence of product recalls, especially in terms of halal assurance, will lead to the level of customer trust and confidence in the integrity of the halal industry

Table A2. *Cont.*

Authors	Year	Findings	Technology in Halal Manufacturing	Firm Performance	
				Financial	Non-Financial
[42]	2023	The study proposes a Halal transaction compliance process using a weighted compliance scorecard (WCS) to determine the permissibility of individual transactions in fintech-embedded e-commerce.	Fintech (Halal Transaction Compliance Protocol)	This fintech can bridge international transactions.	It can assist firms in tracking financial activities.
[54]	2022	The research found that with contributions from all supply chain players, blockchain-enabled halal fashion traceability enables end customers to get comprehensive data from the initial supply chain stage (sourcing) to their wardrobe.	Blockchain Technology	x	Ensuring transparency and security related to Halal Fashion Traceability
[55]	2023	The findings reveal that adopting blockchain technology positively and significantly affects Halal supply chain performance and firm competitiveness	Blockchain Technology	Benefits from the tracking system made possible by blockchain technology include evidence of the transparent flow of finances, information, and goods from producer to customer.	Supporting blockchain technology's accessibility can improve traceability and transparency, connecting upstream and downstream flows that influence improvements in the efficiency of the Halal supply chain's performance.
[57]	2023	The empirical analysis data suggest that knowledge and attitude show a significant impact on the intentions of SME owners to participate in waqf, while religiosity does not have a significant impact on the intentions of Malaysian and Indonesian SME owners to participate in waqf.	Digitalization and advanced technology through waqf funds (Financial Technology)	x	Increase sustainability of MSMEs in Malaysia and Indonesia by 90% through waqf participation
[58]	2023	Findings: A blockchain is identified as having the opportunity to promote value innovation in the halal industry through its features. This study defines a typology model of value innovation-based blockchain for the halal industry that takes place on a particular spectrum.	Blockchain Technology	x	More transparent transaction processes through decentralized protocols can increase the value of innovation in management decision-making in each operation process.

Table A2. *Cont.*

Authors	Year	Findings	Technology in Halal Manufacturing	Firm Performance	
				Financial	Non-Financial
[59]	2023	The study results revealed that synergy and development patterns between Islamic banks and Muslim-friendly tourism should be carried out simultaneously. Six aspects to consider in building and developing the synergy include establishing partnership cooperation, optimizing the role of Islamic bank stakeholders and Muslim-friendly tourism, improving ACES (access, communication, environmental, and service infrastructure), intensifying education and literacy of the halal industry, innovating and transforming technology, and conducting clusters for the halal industry development.	Machine Learning and Digital Innovation Services	x	Adapting this technology will create a new offer to existing customers to be more loyal, and data collection will then be recorded, which ends in deep learning customer engagement always to provide an appropriate and satisfying service
[61]	2022	The study emphasizes the growing importance of a traceability system that is perceived to be easy and useful in the food industry, particularly for ensuring halal compliance.	Halal traceability system	"The use of a halal traceability system would assist our firm in reducing the operating cost".	The adoption of a halal traceability system can enhance SME business and improve the integrity of the halal industry.
[62]	2020	Building an integrated Islamic financial ecosystem is crucial for improving the performance of the halal industry in Indonesia	Financial Technology	x	Increase synergy in the halal industry ecosystem by emphasizing the role of each institution in minimizing the problems related to the halal industry
[64]	2015	Information Technology Outsourcing (ITO) can be a solution to help SMEs in Malaysia accelerate their adoption of e-business, as they often lack the resources and skills to develop in-house IT applications.	Information Technology Outsourcing (ITO)	Lower labor specialization costs while simultaneously raising cash flow and the financial performance index.	Provides detailed factors in the relationship between IT Outsourcing and the company.

Table A2. *Cont.*

Authors	Year	Findings	Technology in Halal Manufacturing	Firm Performance	
				Financial	Non-Financial
[65]	2021	The application of technology can have a positive and encouraging impact on improving the quality of life. The use of technology can improve the economy, education, and the healthcare industry.	Blockchain Technology	x	It can help companies identify the authenticity of halal certification processes to increase trust and ensure the authenticity of halal logos.
[66]	2022	The study provides valuable insights for government bodies and Halal logistics providers to enhance the adoption rate of Halal transportation and improve the Halal supply chain.	Halal Transportation System	Can save transportation costs incurred	The benefits of using the Halal transportation system among Halal food manufacturers are easing the doubts about Halal quality, increasing the image of the products, and another shape.
[20]	2022	Halal warehousing is a frequently emerging area around the world. Technology plays an essential role in halal warehousing. Both the variables of the technology have been found to be significant.	Halal Warehousing System	x	A firm can measure products/goods that are aligned with Halal specifications, value systems, and job responsibilities
[1]	2021	Technology plays a crucial role in managing risks in the HSCM, especially in terms of information management and communication.	Blockchain Technology, IoT, and RFID	x	Implementing technology-driven solutions can help in reducing risks associated with product adulteration, counterfeiting, and non-compliance with Halal requirements
[67]	2020	The research indicated that the D-loop region has potential utility for investigative purposes in the field of halal forensics, serving as the primary mitochondrial DNA segment for comparisons.	Displacement Loop mtDNA	x	Facilitate halal forensic investigations in determining the halalness of critical raw materials (animal)

Table A2. *Cont.*

Authors	Year	Findings	Technology in Halal Manufacturing	Firm Performance	
				Financial	Non-Financial
[68]	2020	No notable differences in brain activity were observed when subjects observed Halal and non-Halal logos. However, significant alterations in the ventromedial prefrontal cortex were detected when meat images were associated with Halal and non-Halal labels. This implies that the impact of the Halal logo on perception is contingent upon its conjunction with a product.	functional Magnetic Resonance Imaging (fMRI).	x	Knowing consumer interest in buying halal products that have a halal logo
[70]	2019	The ventromedial prefrontal cortex activation increased significantly in all participants when exposed to Halal images, whether of raw or cooked meat, possibly due to the heightened emotional sensitivity of Muslim consumers.	functional Magnetic Resonance Imaging (fMRI).	x	Knowing consumer desires in choosing halal products
[72]	2022	This augmented reality application aims to enhance consumer awareness of halal cosmetic products and aid them in making informed decisions when purchasing cosmetic products.	Augmented Reality	The cost incurred to adopt this technology is quite expensive	Increase consumers' awareness of buying halal cosmetics because it gives them experience before buying the product.
[73]	2022	To enhance their success prospects in Muslim markets, marketing managers of multinational companies should employ advertising messages emphasizing the ethical aspects of their products and utilizing cognitive appeals rather than emotional ones.	functional Magnetic Resonance Imaging (fMRI).	x	Facilitate marketing managers in making halal product advertisements by paying attention to the ethical and emotional aspects of customers

Table A2. *Cont.*

Authors	Year	Findings	Technology in Halal Manufacturing	Firm Performance	
				Financial	Non-Financial
[74]	2020	FinTech firms ought to prioritize refining their products to align with Islamic Sharia principles rather than relying on the social environment to attract Muslim consumers for product purchases.	Sharia Fintech	x	Facilitate the tracking of transactions that comply with sharia principles.
[75]	2021	The study results showed that ensuring halal traceability in food products is essential for impacting consumers' buying choices.	Blockchain Technology	x	Ensuring the halal traceability of a product, thus increasing consumer interest in buying the product
[76]	2023	The incorporation of blockchain technology into the management of the halal food supply chain is emphasized as a promising strategy to improve transparency, trust, and integrity.	Blockchain Technology	Can reduce the expenses associated with manual halal traceability processes.	Improve transparency and trust in the supply chain
[77]	2021	This study investigates the application of Blockchain technology to enhance the integration and accountability of data activities among stakeholders in the Halal Assurance System. The utilization of Blockchain aims to improve the traceability of halal products, ultimately fostering consumer trust and increasing awareness of the value of halal products.	Blockchain Technology	Minimize lost costs	Improve integration and accountability of Halal Assurance System stakeholder data activities. Can further increase consumer confidence and awareness of the value of halal products
[78]	2022	Challenges in implementing blockchain technology innovation	Blockchain Technology	x	Improved transparency, traceability, and timely decision-making
[79]	2022	Consumers of halal chicken products will be confident that the chicken slaughterhouse adhered to the halal assurance system in its critical halal-related processes	Blockchain Technology	Increase product sales	Increase the certainty that products have been processed in accordance with applicable halal standards

Table A2. *Cont.*

Authors	Year	Findings	Technology in Halal Manufacturing	Firm Performance	
				Financial	Non-Financial
[80]	2023	The supply chain in a large city presents numerous opportunities to capture and leverage relevant smart data, which can be utilized to enhance efficiency, transparency, and sustainability.	blockchain, Internet of Things (IoT), Artificial Intelligence (AI)	x	Enhanced monitoring and assurance of adherence to diverse standards and sustainability across the supply chain.
[81]	2022	Utilizing appropriate technology can enhance documentation and transparency, proving effective in addressing these issues.	Blockchain Technology	The cost of implementing blockchain technology is quite high	Ensuring transparency in documentation involves effectively recording information and transactions. The system has demonstrated its security and transparency, as all involved parties have public access to transaction details.
[82]	2019	The findings of this research underscore the significance of having a "user-friendly" online search service accessible to Muslim consumers.	Online search service	x	Improving the effectiveness of halal product status search
[83]	2023	various technology platforms devised for the dengue vaccine, the recombinant subunit vaccine, and the DNA vaccine show potential for creating halal vaccine products.	Halal dengue vaccine technology	Affordable price	Improving prevention of dengue fever outbreaks
[84]	2020	The findings indicated a low level of adoption of IoT among halal agro-food SMEs for managing their business operations.	Internet of things	High costs	The implementation of IoT has undoubtedly established a reliable platform for the supply chain of halal agro-food SMEs.
[86]	2019	The primary concept of incorporating DOA with IoT technology gateways is to offer standardized access to diverse information and services related to products, including identification, description, search and retrieval, security, integrity, trust, and data typing.	digital object architecture (DOA) & RFID	x	The system provides effective technical guidelines for companies to monitor the entire product lifecycle using the Internet of Things.

Table A2. *Cont.*

Authors	Year	Findings	Technology in Halal Manufacturing	Firm Performance	
				Financial	**Non-Financial**
[87]	2022	Smart contracts, encompassing traceability, decentralization, and anonymity, are introduced into the model as moderators to investigate their impact on the integrity of the halal supply chain.	Blockchain technology	x	Improve the integrity of the halal supply chain
[88]	2023	We discovered that achieving high accuracy in link prediction is feasible through the utilization of conventional machine learning methods.	Machine Learning	x	Improve the efficiency of checking the difference between halal products and non-halal products.
[89]	2023	Academics and industry practitioners are invited to improve traceability in the Halal supply chain and assurance pathway.	Blockchain technology	x	Improving transparency in halal supply chain and assurance pathways
[90]	2019	As the Halal Food sector experiences growth, organizations need to enhance their supply chain efficiency, and Blockchain emerges as a solution offering increased transparency and assurance of Halal compliance.	Blockchain technology	x	Improving transparency and assurance of halal compliance
[91]	2021	Blockchain technology can ensure the quality and halal attributes of food products.	Blockchain technology	Minimize tracking costs	Tracking speed is up to 10 times faster than conventional methods, leading to minimized losses through more targeted issue resolution.
[102]	2017	Employing NFC and RFID tags, as opposed to barcodes, reduces the risk of fraud in the halal food industry.	RFID and NFC	x	NFC and RFID mobile shopping technologies streamline the validation of halal status, allowing customers to do so effortlessly through their personal smartphones.
[103]	2018	The Muslim consumer's view of online traceability as beneficial is shaped by three key factors: their inclination to trust, commitment to a healthy lifestyle, and the reputation of both the company and certification bodies.	Online Traceability	x	Improve company reputation

Table A2. *Cont.*

Authors	Year	Findings	Technology in Halal Manufacturing	Firm Performance	
				Financial	Non-Financial
[104]	2014	Hybrid Renewable Energy System can minimize the excess energy that occurs during the production process.	Hybrid Renewable Energy System	x	Improving the sustainability of environmentally friendly businesses
[105]	2011	The combination of ICT (RFID) in the halal supply chain can be the answer to tracing and tracing issues in Malaysia.	RFID	x	Improving the integrity of halal products

Table A3. Technology in Halal Procurement.

Authors	Title	Year	Findings	Technology in Halal Procurement	Firm Performance	
					Financial	Non-Financial
[43]		2023	Based on the results of the hybrid method approach (ISM-MICMAC-System Dynamics), the flexibility criterion can influence other criteria. The following criteria are cost and traceability criteria	Blockchain Technology	Increase operational costs	x	Improved product quality due to well-managed traceability management
[50]		2020	The findings indicate that the quality of halal service providers and the retail sector's readiness for technological adoption have a major impact on the effectiveness of halal logistics.	E-procurement technology	x	x	The use of technology can improve performance in order to speed up halal traceability. However, the use of technology needs to be balanced with the ability of employees to use this technology.
[93]	A usability evaluation of an interactive application for halal products using optical character recognition and augmented reality technologies	2023	The integration of blockchain and ERP can enhance corporate governance, leading to improved company performance in the long run.	Blockchain Technology and ERP	Reduce operational cost		Through effective management of halal product procurement, companies can guarantee the delivery of products with halal assurance to consumers.

Table A4. Technology in Halal Logistics.

Authors	Year	Findings	Technology in Halal Logistics	Firm Performance	
				Financial	Non-Financial
[41]	2019	The research highlights the importance of separating Halal and Haram (forbidden) products and considers the chain effect of Haram facilities on the entire Halal food logistics network. Furthermore, the paper investigates the optimal location and allocation of the Halal food logistics network, which includes farms, butcheries, and food plants that follow strict Islamic food regulations.	CPLEX and hybrid genetic algorithm	There are indications of an increase in costs in developing a halal logistics network. This is influenced by the amount of distance traveled. However, the increase in total network development costs does not mean that each cost element continues to increase	Improve the efficiency of locating farms, butcheries, and food plants
[44]	2023	The research results revealed the PLS warehouse process flow, their halal implementation in warehouse management, and their perception of the importance of halal warehouse practice for halal pharmaceutical products. This could offer significant insight to the manufacturers, patients, users, researchers, or academicians.	Pharmaniaga Lifescience (Cold rooms)	x	Increase efficient halal document checking and verification process
[47]	2021	The study highlights the importance of technology readiness in improving customer satisfaction and organizational operations in the halal meat industry.	Internet of Things (IoT), RFID, and EDI	x	The use of technology in halal logistics can improve the quality of information, the quality of personnel contact, order accuracy, order conditions, order discrepancies, and order expenditure amount.
[53]	2022	The development of a digitally enabled community in ASEAN, represented by internet and mobile phone users, may have a significant impact on the region's potential to become a global leader in halal logistics.	Information and communication technologies (ICT)-Digitally-enable community	x	Improve the efficiency with which halal logistics are conducted, offer improved logistical organization, and boost halal performance.
[60]	2023	Building a Halal logistics brand through traceability technology and Halal training is crucial for logistics service providers to stand out in the competitive market and attract Sharia compliance-oriented consumers.	Halal Traceability Technology (Product ID and RFID)	x	The usage of Halal traceability technology in Halal logistics can significantly improve the performance of logistics service providers and enhance the market recognition of their Halal logistics brand.

Table A4. *Cont.*

Authors	Year	Findings	Technology in Halal Logistics	Firm Performance	
				Financial	Non-Financial
[63]	2020	The emergent resource-capability of halal logistics services significantly impacts customer service innovation and cost advantages. Halal-based third-party logistics providers should focus on developing their resource capability to enhance competitiveness in the dynamic halal market.	Halal-based third-party logistics (3PL) providers	x	Halal-based 3PL providers with high and medium resource capabilities achieve greater customer service innovation and cost advantages significantly
[69]	2021	The paper suggests a conceptual framework named Traceability-Technology-Training (3T) as a directive for regulatory bodies to endorse company-level halal logistics initiatives through a bottom-up approach.	Blockchain technology	x	Improve efficiency in traceability during the logistics process so as to minimize product contaminations
[100]	2014	The use of ICT (RFID) can help companies in monitoring their transportation.	Information Communication Technology (ICT)-RFID	x	Improve the effectiveness of monitoring halal transportation

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