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Review

Exploring the Hype of Blockchain Adoption in Agri-Food Supply Chain: A Systematic Literature Review

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Abstract: This study examines the effect of blockchain adoption on the agri-food supply chain. A systematic literature review approach was used to analyze and synthesize the findings from the existing literature, focusing on fundamental research themes, research gaps, and the direction of future research on the impact of blockchain adoption in the agri-food supply chain. Twenty-seven full-length articles were considered and thematically analyzed in this study. The authors identified eight themes from the literature, including factors responsible for blockchain adoption and new research areas such as digitalization and the impact after adoption. These themes shed light on the agri-food supply chain practices following the adoption of blockchain technology. Moreover, this study provides a foundation for strategic and policy initiatives in the agri-food industry involving blockchain technology. The findings indicate that critical factors driving blockchain technology adoption in the agri-food industry include ensuring food traceability and transparency, food safety and security, food supply and logistics, food integrity, environmental awareness, and reducing food waste. Additionally, this study highlights the importance of guidelines and policy-level involvement after adopting blockchain technology, particularly in facilitating accurate quantification and promoting digitalization to address challenges and streamline processes. The study concludes by suggesting future research avenues for blockchain technology in the supply chain domain.

Keywords: agri-food industry; blockchain technology; supply chain; systematic literature review

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Citation: Yogarajan, L.; Masukujjaman, M.; Ali, M.H.; Khalid, N.; Osman, L.H.; Alam, S.S. Exploring the Hype of Blockchain Adoption in Agri-Food Supply Chain: A Systematic Literature Review. *Agriculture* **2023**, *13*, 1173. https://doi.org/10.3390/agriculture13061173

Academic Editors: Hung-Hao Chang, Pei-An Liao and Jiun-Hao Wang

Received: 26 April 2023
Revised: 19 May 2023
Accepted: 23 May 2023
Published: 31 May 2023

1. Introduction

Blockchain technology (BT) is an important topic due to its recent high expansion in modern agriculture. The prominence of BT in the agri-food supply chain (AFSC) ensures transparency, real-time information on any product, fraud circumvention, manipulation resistance, reduced operational costs, audibility, enhanced product quality, safe and healthy consumption, and a more structured certification process [1]. Although blockchain technology appears favorable in several sectors, it is still hard to apply due to its convolution [2]. The awareness of BT is high and it is argued to be easy to use. From the context of the AFSC, there are still obstacles faced by the supply chain members when they start implementing blockchain technology in their operations. For example, Rejeb et al. [3] highlighted significant barriers, such as technical, organizational, and regulatory challenges, that diminish the potential of the AFSC and impede BT adoption. However, BT has been working in other industries, yielding favorable output to adopters [4]. The mixed findings on the impact of BT, especially between agri-food and other industries, indicates the embryonic stage of BT in the agri-food industry [5]; therefore, it warrants further exploration in this context, especially of the impact of BT adoption in the AFSC.

Recently, a large amount of research has emerged regarding blockchain adoption and the food supply chain (FSC). Even within the specialist literature on BT in the AFSC, this study mainly focuses on application, identification, evaluation, and interpretation. For instance, the literature aims to provide a clear definition, necessary elements, challenges, and drivers of BT among practitioners [2,6]. In short, the literature argues that it is a major challenge to make BT more accessible, as is the case for similar technologies such as the Internet of Things (IoT), big data, radio frequency identification (RFID), robots, sensors, etc. Similarly, in terms of how these technologies can be integrated into BT [7], Ali et al. [5] argued that the compatibility of these technologies with BT is promising; thus, a clear regulatory framework should be developed to ease the process during blockchain adoption and implementation in the AFSC [2]. Following this line of argument, scholars have tried to assimilate the impact of BT adoption to the entire FSC [8]. For instance, Turkey has started implementing blockchain technology in their dairy farms [9]. However, public awareness of such efforts and their featuring of BT is still shallow.

Scholars [3,6] highlighted that the impact of BT adoption on the AFSC is vague, complex, and multifaceted and requires attentiveness from the members of the AFSC such as producers, processors, wholesalers/distributors/suppliers/, retailers, and consumers, including society and policymakers. The complex nature of BT adoption is at the embryonic stage and complex for the AFSC, and the previous literature is yet to provide a holistic understanding of the topic. Therefore, a clear research framework requires development; this study uses a systematic literature review (SLR) to analyze and assimilate extant work carried out on BT in the AFSC [10]. In a nutshell, this study's research questions are summarized as follows:

- RQ1: What is the research profile of the relevant prior literature concerning the impact of implementing BT in the AFSC?
- RQ2: What research themes are related to the issues examined in the existing literature concerning the impact of BT adoption in the AFSC?
- RQ3: What are the research gaps and limitations of the prior literature on BT in the AFSC?
- RQ4: How can future BT researchers in the AFSC expand their research and develop a comprehensive research framework?

Several SLRs are being carried out on BT in the AFSC. For example, Mangla et al. [9] reviewed the societal impact of BT in milk supply chains using the system dynamic technique (Table 1). The research of Rejeb et al. [3] identified potential regulatory, technical, and organizational challenges during BT adoption in the AFSC. Yang et al. [8] discussed the challenges and remedies of BT adoption. In addition, more technical studies are related to the types of BT platforms used for the AFSC to gain coordination mechanisms [11,12]. Several other studies focused on issues related to BT adoption, such as scalability, privacy, incentivization, and regulations [13], and industrial case studies with impacts and challenges have started applying BT in their operations [2,3,9]. Moreover, BT adoption in the AFSC literature is also discussed from different perspectives, such as stakeholder adoption behavior [11], societal impact [9], and performance impact [6]. Thus, this study can provide a more detailed analysis of preceding studies by focusing on the impact of BT adoption and implementation across the AFSC.

Table 1. Existing research on BT in the supply chain.

Sources	Methodology	Findings	Limitations
[6]	Literature overview and exploratory case studies (primary data)	• Blockchain technology platform types (BCTPT) differentiated through coordination mechanism. • Tested performance impact.	The impact of BT on supply chain networks was not addressed.
[11]	Qualitative analysis/ Exploratory research	The normative stakeholder management approach positively impacts the use behavior of BT.	Only used the societal factors of adoption of BT and the contextual factors were ignored.

Table 1. *Cont.*

Sources	Methodology	Findings	Limitations
[12]	SLR/Primary data	• Mapped out how BT has evolved with respect to its usage in the supply chain sector. • Sectoral adoption, types of BT adopted, and the status of an organization adopting successful projects.	Missed out on elaborating on the implementation challenges and their potential mitigation strategies.
[9]	Qualitative study/Case study	• Reviewed the societal impact of BT in milk supply chains using the system dynamic technique. • Explored challenges that have started applying BT in their operations.	Did not use the holistic view. Used only factory (firm) perspective; the end consumer context is missing. Performance analysis using BT in specific supply chain units is also omitted.
[8]	Qualitative studies/ Analytical analysis	• Discussed the values and impact BT had on retailing, suppliers, and consumers during the COVID-19 outbreak. • Pricing, incentives, and required investment for implementation were also addressed.	• Strategies and policies implementing BT were not discussed. • Various modes of BT implementation and involvement were not focused on.
[2]	Literature review	• Showed impacts and challenges that have started applying BT in their operations using industrial case studies.	The mitigation strategies and policies to overcome the challenges were left out.
[3]	Systematic review/ Bibliometric analysis	• Identified potential regulatory, technical, and organizational challenges during BT adoption in the AFSC. • Discussed the constraints that have started applying BT in their operations.	Selected only Scopus literature data and omitted the WOS data based on retrieving articles.
[13]	Quantitative study/ Primary data	Found the effects of data-driven supply chain capabilities (scalability, privacy, incentivization, and regulations) on financial performance.	Did not discuss the adoption factors, and failed to show the holistic view and other nonfinancial impacts.

The topic of the impact of BT adoption in the AFSC is multidisciplinary and interdependent. Moreover, affiliated studies appear in journals with various disciplines and audiences. Thus, the topic remains highly important. The findings and results of the present study can gain interest from a wide range of researchers, policymakers, and practitioners as it is a comprehensive study of the research-driven study literature. Researchers and scholars can gain interest in understanding more about the topic of interest as it has not gained much attention from the research community. Practitioners can use the present study to know more about the impacts of blockchain adoption in the AFSC and prioritize approach fields of action. Likewise, policymakers should undertake the necessary ideas to develop policies concerning the impact of BT adoption in the AFSC. Thus, this SLR significantly contributes to upcoming practices and theories.

This paper is structured as follows. Section 1 outlines the introduction. Section 2 defines the boundaries of the review. Section 3 focuses on methodology and research profiling. Section 4 presents the thematic foci. Section 5 exhibits research gaps and directions for future research. Section 6 focuses on the development of the framework. Section 6 configures the conclusion, implications, and limitations, with recommendations for future SLRs.

2. Status of AFSC Research and Scope of This Review

The agriculture industry has been in the foreground of exploring BT since its introduction as a favorable technology that may benefit the supply chain. The AFSC has diverged from other types of supply chains since it deals with more crucial issues such as interactions with supply chain members, commodities of a perishable nature, and inter-sectoral influence from farm to fork [5]. The crisis connected with the AFSC involves its transparency, visibility, sustainability, safety, efficiency, and the quality of the processes [14]. Researchers have confirmed that the AFSC relates globally to relevant stages, including farm production, storage and handling, processing, retailing, and consuming [15]. Inefficiencies in the AFSC, such as the complexity of goods exchange, high-risk development between buyers and sellers during exchange value, logistics expenses, and issues tracing the environmental footprint and product origin, are among the potential areas to which BT could provide a solution [7]. Previous studies contend that the initial stages of FSC contribute the utmost towards BT adoption [7]. Initially, BT was adopted in the AFSC due to its four main benefits, which are "information transparency", "food traceability", "recall efficiency", and "efficiency after IoT combination" [16]. A previous study has contended that BT adoption has contributed significantly to the AFSC industry [8]. This, however, has been contested in BT literature, which suggests that poor handling still exists after the technology's adoption (i.e., in Africa [2], China [17], and Turkey [9]), mainly due to the complexity of the blockchain system itself.

Understanding the impacts brought by BT adoption is difficult as it involves several peripheral impacts. The prior literature suggests that although blockchain implementation has provided various benefits, it still has drawbacks after implementation [3] (Table 1). Scoping the BT adoption concept and extending the suggestion of Kamilaris et al. [7], Rogers and Ban, and [18,19], the present study illustrates the five adoption stages of blockchain technology that connect the scope of BT applications in AFSC operations among the members of the AFSC.

The first stage is based on laggards, which represent the producer of the AFSC. Farmers are usually the producers of the AFSC. Farmers are known as laggards in blockchain adoption because they are unfamiliar with BT, comfortable with traditional methods, and lack knowledge and skills in BT [2]. Farmers oversee seeding, fertilizing, crop cultivation, checking weather conditions, and caring for animal and plant welfare [7]. All this information requires storage in the blockchain, which is difficult as they are not used to the system [2]. Mostly, farmers in rural areas should be informed and taught about innovation [19].

The second stage is based on the late majority, representing the processor as the processing stage is more concerned with transforming the primary product into secondary products. It involves packaging, which provides all relevant information such as processing procedure information about the raw materials used in the product. The processors decide to implement [7] the innovation by looking at the development of its adoption among other members of the AFSC [19].

The third stage is based on the early majority, representing the distributor—the third member of the AFSC. Distributors are usually responsible for taking care of the product and storage conditions such as temperature and humidity while providing shipping details and time in transit at each transport used to deliver the product [7]. The distributor is categorized as the rare leader, whereby they adopt BT after acknowledging its adoption by other members of the AFSC. They are also the decision makers who decide on implementing the innovation [19].

The fourth stage is based on the early adopters. Early adopters represent the retailer, the fourth member of the AFSC. Retailers usually provide all the information consumers need (expiry dates, product quality, product origin, storage conditions, and time spent on the shelf) on the package [7]. Retailers are known as early adopters as they are the opinion leaders in the chain. They are aware of the changes and demands from the consumer that lead them to adopt changes, including adding blockchain features at the retailing level. Retailers are the members of the AFSC that implement the innovation to provide all relevant information to the consumer [19,20].

The final stage represents the consumers, who are the innovators that are willing to learn and take risks to accept and develop new ideas. Consumers usually connect to the internet through mobile phones to scan quick response (QR) codes for detailed information about the product's origin [7]. In the AFSC, the consumers are linked as the innovators as the consumers are the final supply chain members that demand transparency and traceability about the product's origin. Thus, consumers are the first party to adopt blockchain features to obtain all the relevant information and can confirm whether the technology can be assumed [19].

To this end, the current study only emphasizes the motive to adopt blockchain technology and the stages involved for generic AFSC members. As discussed above, blockchain adoption focuses on the five steps of time constructed in the diffusion of innovation theory, which are knowledge, persuasion, decision, implementation, and confirmation, by explaining the information collected and stored in the blockchain under each member of the AFSC (i.e., producers, processors, distributors, retailers, and consumers), respectively.

3. Methodology

This study intends to use the SLR methodology, focusing on a well-defined and well-planned protocol. SLR development consists of two phases. The first phase includes keyword (as presented in Table 2) search and execution of documents search using the Web of Science database, including the inclusion and exclusion criteria (as presented in Table 3) of database search [21]. The second phase presents and discusses the findings from the results of SLR.

Table 2. Keywords for literature research.

BT Adoption-Related Keywords	AFSC-Related Keyword	Search String
Blockchain adoption Blockchain implementation Blockchain adoption impact Blockchain implementation impact	Food supply chain Agriculture Agri-food supply chain Supply chain	"Blockchain adoption impact in AFSC" or "Blockchain implementation impact in AFSC" or "Blockchain adoption impact in agriculture" or "Blockchain implementation impact on Food Supply Chain"

Table 3. Study inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Articles published in English from the year 2018 to the year 2022; Articles focusing on aftermath of BT adoption and implementation in AFSC; Peer-reviewed articles; Articles focusing only on aftermath of BT adoption in AFSC or FSC only.	Studies on blockchain implementation in other than AFSC or FSC industries; Proceedings papers, book chapters; Articles written other than in the English language; Duplicated articles.

3.1. Review Planning

The authors of this study selected the Web of Science database after setting initial keywords to search relevant studies related to the impact of blockchain adoption in AFSC. The search was continued by selecting leading journals in agriculture, food supply chain, food, and blockchain adoption to ensure the chosen keywords were all-inclusive. A review panel was established to provide the profiling and rigorous selection of articles. Developing a review panel to set conceptual boundaries for a review is essential. Three experts were included as the review panel members (two professors and one researcher).

This panel debated, agreeing on selected keywords to prepare the final list. This study used two primary databases, Web of Science and Scopus, in line with Derwik et al. [22].

3.2. Specifications of the Study

The inclusion and exclusion criteria were applied in Table 3 to obtain the study specifications using a database search. The central inclusion criteria of articles were publication between 2018 and 2022 and only in the English language. We did not consider articles in other languages. We only considered articles that are only peer-reviewed and focus on BT in AFSC (limited to our themes only). We only considered published full-text articles and excluded proceedings papers, book chapters, and duplicated articles.

3.3. Data Extraction

Boolean logic was applied by selecting the keywords from the final list and rebuilding them into a search string by applying the "Or" and "And" connectors. Using the transformed search string, the authors searched for journal titles, abstracts, and keywords using the WOS database. The search focused on articles published from 2017 to November 2022. The study of Vadgama, & Tasca [12] stated that the peak time of blockchain projects being created was in 2018, and 35% of the market-ready projects were intended to be implemented in 2017. The authors found 112 articles related to the impact of adopting BT in AFSC. From this list, 25 duplicated articles were removed from the database. Then the authors continued by removing all proceedings papers, followed by articles not published in English. The next step was applied using inclusion and exclusion criteria, which reduced the total number of articles in the dataset to 87.

To verify the articles' input in more detail, the review panel screened them thoroughly using an Excel sheet and finalized the articles by reviewing the titles, abstracts, and keywords. To ensure a vigorous screening protocol, each panel screened the Excel sheet individually and discussed the articles that were short-listed individually by each panel to come up with a final agreement. From the discussion, 46 articles were removed as the panels found them to meander from the conceptual boundaries and scope. The researchers conducted forward and backward chaining citations for each article to ensure vigorous screening protocol and reduce the chances of missing relevant articles. Fourteen articles were detected from the chaining citation, including proceedings papers. After a complete screening set, 27 full-length articles were finalized (Figure 1). The following parts of SLR comprise the data execution process by discussing the results of research profiling and content analysis.

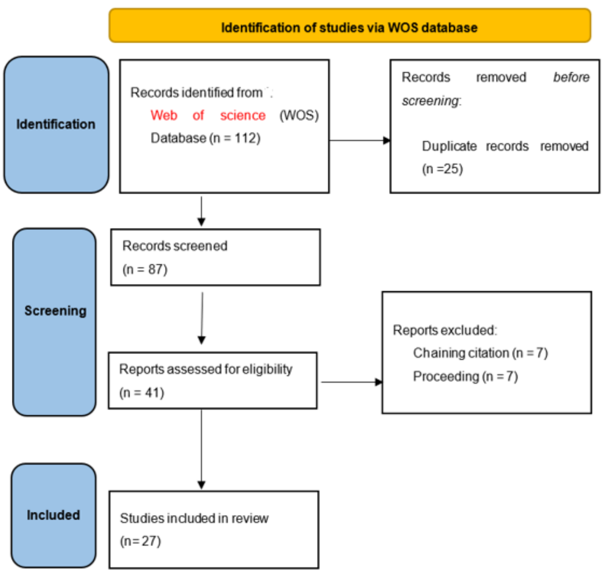

Figure 1. Schematic view of the stages and their criteria.

3.4. Data Execution: Research Profiling

This study, using research profiling, suggests that the literature about the impact of blockchain adoption is relatively new, as the number of publications started increasing in 2018. The most productive authors are depicted in Figure 2. Focusing on the study design, most studies were qualitative—68%, as shown in Figure 3. This is an apparent result since a significant amount of literature is focused on ex ante and ex post of blockchain adoption and comprises an analysis using primary and secondary data.

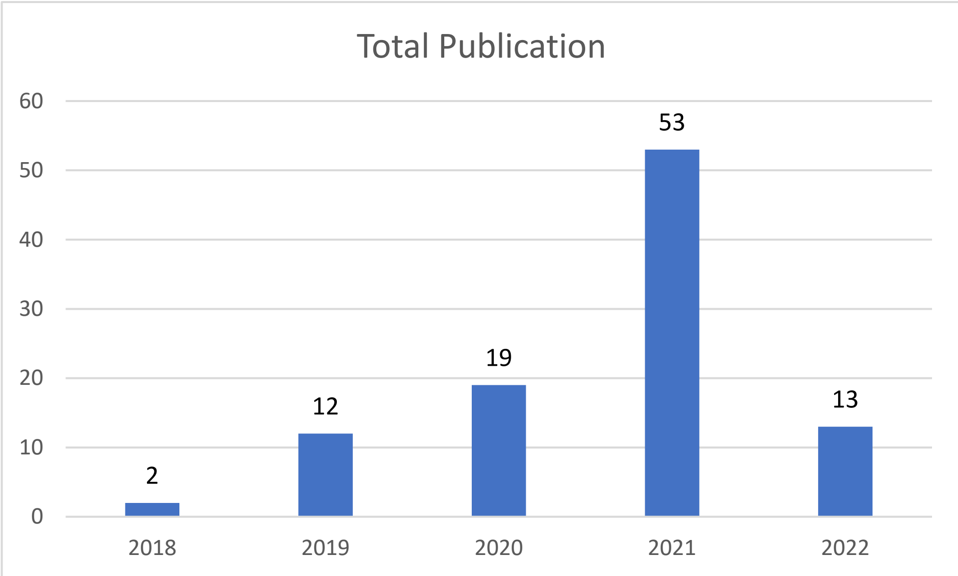

Figure 2. Year-wise publications.

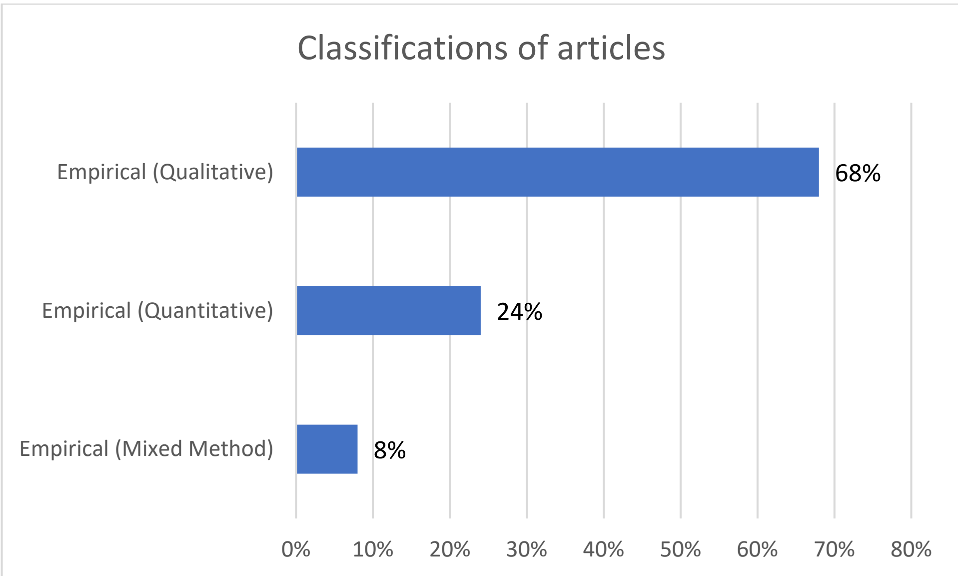

Figure 3. Classifications of articles.

4. Thematic Foci

Providing deep and comprehensive insights from the existing literature to improve our understanding towards the impact of blockchain adoption in the AFSC was the objective of the review. Thus, a few researchers developed themes separately. After insightful discussions, they finalized seven broad themes. Other themes were clustered into eight, focusing on different elements from blockchain adoption in the AFSC. The themes are illustrated in Figure 4.

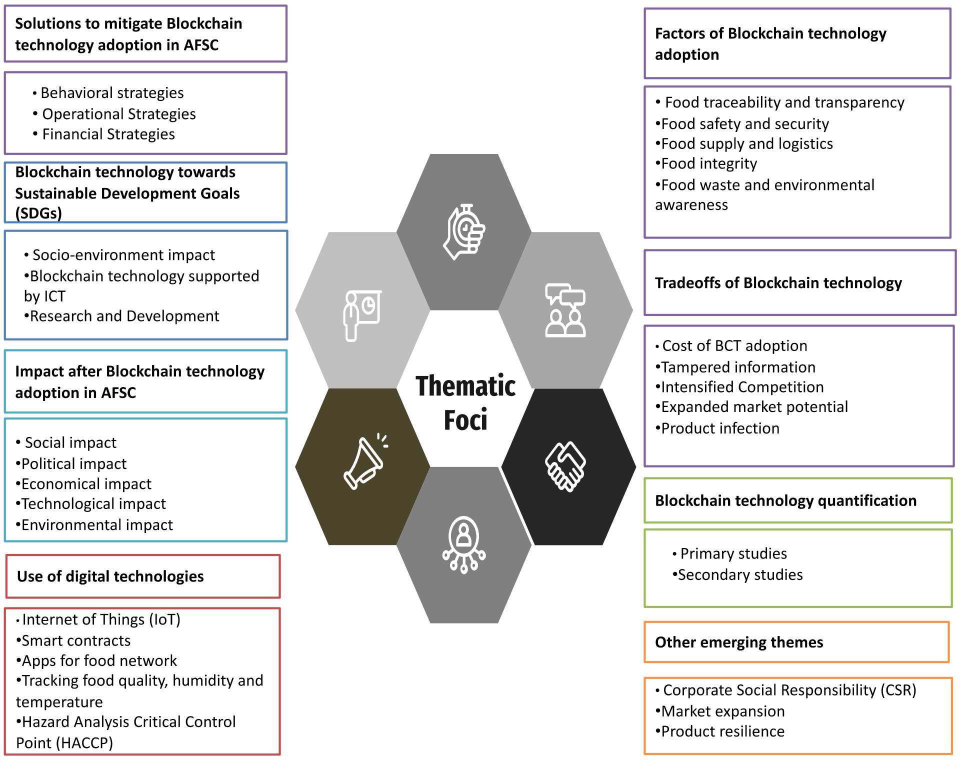

Figure 4. The selected themes of this study.

4.1. Factors of Blockchain Adoption

Adopting BT is crucial for business success, particularly for the supply chain industry. Scholars have optimized aspects such as the compatibility between the organizational need and the BT specification, the interoperability of technology within multiple systems, and the adopters' technology maturity level, which are crucial to avoiding misalignment of rationality and the reality of needs [16,23–25].

Analyzing factors that cause blockchain technology adoption is of topical interest in the extant studies. The extant literature that focuses on the factors responsible for BT criteria generation is divisible into particular streams, such as the stream of literature that deals with enlisting many factors that lead to high blockchain technology adoption generation in the AFSC [7,16,23–25]. Furthermore, during this review, we compared the selected 27 articles thoroughly and classified the factors which appear repetitively in the literature as predictors of BT adoptions. Some of the major sources of blockchain technology, as these studies indicate, include food traceability and transparency, food safety and security, food supply and logistics, food integrity, and food waste and environmental awareness, which can encourage blockchain technology adoption in the AFSC (Table 4), and are discussed as follows:

Table 4. Summary of the key aspects based on thematic foci [6–9,11,12,16,17,23–43].

No	Themes	Subthemes	Explanation	References
1.	Factors of blockchain adoption	Food traceability and transparency	Ensuring data availability, enhancing security measures, enforcing immutability.	[7,23,24,32]
		Food safety and security	Detect and prevent food contamination and food fraud using blockchain technology.	[6,23,30,32]
		Food supply and logistics	Processes and systems involved in the production, distribution, and management of food from its source to the consumers.	[24,31,33]
		Food integrity	Ensuring trust in food exchange activity.	[7,34]
		Food waste and environmental awareness	Ensuring waste reduction through the food management process.	[7,26,35]

Table 4. *Cont.*

No	Themes	Subthemes	Explanation	References
2.	Impact of blockchain adoption in agri-food supply chain (AFSC)	Social impact	Influence that an individual, organization, or initiative has on society or specific communities.	[9,24,28]
		Political impact	Influence and consequences that political decisions, actions, or events have on individuals, communities, societies, and governance systems.	[2,12]
		Economic impact	Consequences and effects that economic activities, policies, or events have on the economy of a country, region, or community.	[8,17,24]
		Technological impact	Effects and consequences of technological advancements, innovations, and the widespread use of technology on individuals, societies, and various sectors of the economy.	[2,8,28]
		Environmental impact	Effects and consequences of human activities on the natural environment and ecosystems.	[36]
3.	Blockchain quantification	Primary studies	Primary research, or original research, refers to research studies conducted by researchers or individuals to gather new data or information firsthand.	[27,37,38]
		Secondary studies	Secondary research studies, or literature reviews, involve the synthesis and analysis of existing research and data from primary studies conducted by other researchers.	[16,28,29]
4.	Trade-offs with blockchain technology adoption in agri-food supply chain (AFSC)	Cost of blockchain technology adoption	Blockchain technology streamlines processes, reduces paperwork, and automates transactions through smart contracts. These efficiency gains can result in cost reductions, enabling companies to offer products or services at lower prices.	[8,17]
		Tampered-with information	BT, by design, is resistant to tampering and manipulation of information. The decentralized and distributed nature of blockchain, coupled with its cryptographic algorithms and consensus mechanisms, makes it extremely difficult for malicious actors to tamper with data recorded on the blockchain.	[8]
		Intensified competition	BT enables direct peer-to-peer transactions without the need for intermediaries, such as banks, payment processors, or centralized marketplaces. This disintermediation reduces barriers to entry and allows new players to enter the market, challenging traditional incumbents.	[17]
		Expanded market potential	Startups and entrepreneurs can leverage blockchain's capabilities to develop novel business models, disrupting traditional industries and challenging incumbents.	[17]
		Product infection	Blockchain technology can be used to verify the authenticity of products and components. Each item can be assigned a unique identifier or digital signature recorded on the blockchain, ensuring that counterfeit or infected products can be easily identified.	[8,17]

Table 4. *Cont.*

No	Themes	Subthemes	Explanation	References
5.	Use of digital technologies	Internet of Things (IoT)	By integrating blockchain technology with IoT devices, sensors, and other data sources, it becomes possible to track the entire journey of a product from its origin to the end consumer. This enables quick identification of the source of infection or contamination, allowing for targeted recalls and minimizing the impact on consumers.	[7,32]
		Smart contracts	Blockchain technology provides the underlying infrastructure for secure and transparent data storage and transfer, while smart contracts enable the automation and execution of predefined rules and agreements on the blockchain. Together, they offer new possibilities for building decentralized and efficient systems across various industries.	[30]
		Apps for food network	Blockchain can enable end-to-end traceability in the food supply chain, from the farm to the consumer's table. By recording each transaction and movement of food products on the blockchain, stakeholders can easily track and verify the origin, quality, and handling of the food.	[39]
		Tracking food quality, humidity, and temperature	Blockchain-based apps can facilitate direct communication between consumers and food producers including tracking food quality, humidity, and temperature.	[32]
		Hazards analysis critical control point (HACCP)	Blockchain's immutability ensures that once data are recorded on the blockchain, they cannot be altered or tampered with. This feature helps maintain the integrity of HACCP records, making them trustworthy and reliable for audits, investigations, and compliance purposes.	[7,32]
6.	Solution to mitigate challenges after blockchain technology adoption	Behavioral strategies	Conscious actions and approaches are taken by individuals or organizations to influence or modify human adoption behavior.	[11,31]
		Operational strategies	Plans and methods are implemented by organizations to optimize their operations and achieve their objectives efficiently.	[6,26,28]
		Financial strategies	Deliberate plans and actions undertaken by individuals or organizations to manage their financial resources and achieve specific financial goals.	[25,30,36]
7.	Blockchain technology towards Sustainable Development Goals	Socioenvironmental impact	Blockchain enables transparent and traceable supply chains, allowing consumers and stakeholders to verify the origin, authenticity, and sustainability of products. This transparency promotes ethical sourcing, fair trade practices, and environmentally responsible production.	[29,36,40]
		Blockchain technology supported by information and communication technology (ICT)	Both blockchain technology and ICT share the goal of decentralizing systems and reducing dependencies on central authorities. ICT, through networking and communication technologies, enables the decentralized exchange and sharing of information.	[24,29,36]
		Research and development	Blockchain technology can ensure the integrity and traceability of research data by providing an immutable and transparent ledger. Research findings, experimental results, and data can be recorded on the blockchain, making them tamper-proof and auditable.	[9,24]

Table 4. *Cont.*

No	Themes	Subthemes	Explanation	References
8.	Other emerging themes	Corporate social responsibility (CSR)	Blockchain technology can improve transparency and accountability in charitable donations.	[6,41,42]
		Market expansion	Blockchain technology can enable decentralized marketplaces that connect buyers and sellers from around the world without the need for intermediaries.	[9,17,43]
		Product resilience	Blockchain technology enables end-to-end traceability of products, allowing businesses and consumers to track and verify each stage of the agri-food supply chain (AFSC).	[16,24,43]

4.1.1. Food Traceability and Transparency

The first category focuses on food traceability and transparency which connects the producer who provides all the information about the product's origin, such as raw materials (seeds, fertilizers, feeds, and animal breeds) [7]. Researchers [25,26] admitted that BT offers trackability and transparency in the food supply chain, and stakeholders choose the system accordingly. Dehghani et al. [27] discovered that adopting BT is mainly driven by performance expectancy (PE), transparency, and traceability. These factors have a significant positive impact on the decision of organizations to adopt BT. In other words, organizations are more likely to adopt BT if they perceive it will improve their performance, provide transparency, and enhance traceability.

Ghode et al. and Adamashvili et al. [25,28] argued that BT is valuable for establishing traceability systems and safeguarding production against fraud and contamination. They emphasize that the ability to trace products from the supplier to the end consumer is crucial for ensuring consumers' health and saving lives, which can significantly impact the success of affected businesses. Using a traceability system is beneficial for products with a higher risk of contamination, such as medicine, dairy, and meat [16]. When the risk of contamination is elevated, a traceability system ensures transparency in the production and operational processes [29]. Tsolakis et al. [24] concluded that BT could enable a reliable traceability system in end-to-end supply networks by sharing critical data among all actors involved in the Thailand fish industry. For instance, upstream suppliers can enhance their relationships with corporate customers, increasing business opportunities. Meanwhile, downstream customers can access reliable data that help prevent fraud and ensure food safety, which provides transparency, leading to business growth in local fish industries and the population's welfare. Pranto et al. [30] and Stranieri et al. [31] claimed that implementing BT can provide various benefits, including ensuring data availability, enhancing security measures, enforcing immutability to prevent data tampering, and promoting trust among both producers and consumers.

4.1.2. Food Safety and Security

The second category is food safety and security, which connects to the processors who take responsibility for food packaging to provide the product information, including the list of raw materials used via the coding process on the package [7]. Food safety refers to handling, processing, and hygienically storing food to prevent illnesses in the human population. The use of BT could offer a practical solution to address the pressing need for improved traceability and transparency in ensuring the safety of food products. A number of scholars [23,32] affirm that BT will enhance the safety and security for which it is used in the food supply chain. Through the use of blockchain technology, data manipulation can be prevented, thereby ensuring security. This gives consumers complete confidence in the origin and distribution history of products, while farmers can also access the storage history of seeds [30]. Additionally, governing bodies can use these data to regulate the market. The IoT monitors the entire system, and the blockchain guarantees absolute security [30].

Kramer et al. [6] found that food safety concerns are a significant factor driving the adoption of BT in the agri-food industry. The ability of blockchain technology to detect and prevent contamination or food fraud in the supply chain and facilitate rapid product recalls has led to increased implementation of blockchain projects in the agri-food sector [32].

4.1.3. Food Supply and Logistics

The third category is food supply and logistics, which connects to the distributor. Once the packaging and the coding process are completed, the product is prepared for distribution. Distribution is performed once the delivery time has been set within a certain period, as there might be a storage step for the product [7]. Furthermore, BT leverages total quality management efforts. BT can enable real-time supply network capabilities such as visibility and data-enabled product quality reporting in the fishing industry, enhancing network performance and competitiveness [33]. Tsolakis et al. [24] stated that integrating additional sensors and automation in the blockchain can inspire total quality management to incorporate devices' certification and calibration. Likewise, the research by Stranieri et al. [31] expressed a positive view towards BT, noting that it can enhance extrinsic food quality attributes and facilitate improved information management across food chains. This is attributed to the improved accessibility, availability, and sharing of information enabled by BT. Finally, Dehghani et al. [27] admitted that standardization predicts BT adoption decisions strongly.

4.1.4. Food Integrity

To ensure food integrity, retailers play an essential role by providing the correct information to the customer. For example, Carrefour, one of the famous retailers in Europe, verifies standards and origin traceability in various categories such as dairy products, fish, meat, fruits, and vegetables [44]. The concept of food integrity revolves around ensuring a trustworthy exchange of food within the supply chain, where all actors are responsible for providing comprehensive information regarding the origin of goods, as stated by Kamilaris et al. [7]. In addition, BT is being evaluated for its potential to track the production of nonedible crops, which are susceptible to integrity concerns due to regulatory and legal considerations [7]. The quick and efficient traceability system provided by BT has the potential to identify unethical suppliers, unfair labor practices, and counterfeit products in the wine food chain, indicating a promising future for this technology [34]. Adamashvili et al. [28] proposed that implementing BT necessitates various stakeholders' participation throughout the supply chain. These stakeholders engage in peer-to-peer transactions, enhance accountability, reduce corruption, and generate value for firms and local communities. Furthermore, BT can promote ethical issues such as fair trade and animal welfare through inclusive development, ensuring small producers' access to better markets and secure payment or financing opportunities, as illustrated by FairFood and AgriLedger. Several studies, including those of Bhat et al., Kayikci et al., and Luzzani et al. [23,32,34], pointed out that BT enhances the trust between suppliers and consumers upon proper use.

4.1.5. Food Waste and Environmental Awareness

The fifth category ensures food waste and environmental awareness, whereby the consumers who are the end users of the chain, who buy and demand traceable information, need to acknowledge waste management. For instance, a global recycling venture known as Plastic Bank [45] founded a recycling program in Canada to reduce plastic waste, which is to be applied as well in developing countries [7]. This strategy eventually rewards the public via digital blockchain tokens for whoever brings plastic rubbish to recycling centers [35]. BT offers advantages to various stakeholders involved in the agri-food system, specifically in the global cocoa supply chain. Its implementation can enhance supply chain performance by reducing food loss and waste. Kayikci et al. and Luzzani et al. [32,34] commented that the increased transparency and traceability allowed by BT could ensure waste reduction through the production process.

4.2. Impact of BT Adoption in AFSC

4.2.1. Social Impact

Looking at social impact, Mangla et al. [9] analyzed a dairy farm in Turkey on how BT implementation has impacted the dairy farm's farmers and found that BT has provided many benefits to the dairy farm. Among the benefits brought by BT to society are the following: (1) reducing food fraud, (2) improving the welfare of animals, (3) increasing food security, and (4) providing transparency to the customers. The benefits acclaimed for spurring the social impact are not eminent because the public is unaware of BT's implementation and features. On a similar note, Mangla et al. [9] suggested improving public awareness through educating people on the elements of the blockchain to avoid them from getting trapped in food fraud. Even with the hype of the impact brought by BT towards society, there is a high possibility of specific organizations and suppliers adopting BT cutting corners by not providing accurate information in the system. Suppliers who source their products from unsafe channels tend to tamper with such details before adding them to the BT system [8]. Such behavior has led towards trust issues among members in the supply chain that impede the adoption of BT, hence resulting in swaying away from the primary goal of adoption.

The adoption of BT has significant social implications, including creating new business models, reorganizing existing models, and introducing new systems and skill sets [24,28]. Adamashvili et al. [28] suggested adopting BT requires multiple stakeholders along the supply chain who engage in peer-to-peer transactions, reduce corruption, increase accountability, and create value for firms' local communities. They also pointed out that adopting BT can promote ethical issues such as fair trade and animal welfare through inclusive development that ensures small producers' access to better markets and safe payment or financing opportunities, as exemplified by FairFood and AgriLedger. According to [24], BT can establish end-to-end supply networks in the Thai fish industry, allowing upstream and downstream suppliers to enhance their trustworthy relationships with corporate and downstream customers to leverage the welfare of the local population through increased transparency.

4.2.2. Economic Impact

Niu et al. [17] have stated that BT adoption is expensive, so they have to develop a few solutions, such as increasing the procurement price and improving e-tailing as an option. On the other hand, Yang et al. [8] have justified that the blockchain cannot support cost-sharing contracts and revenue sharing in supply chain coordination during blockchain adoption. The Adoption of the blockchain causes incentive conflict between local and overseas suppliers due to a higher procurement price that affects the market share and profit margin due to the high cost of blockchain adoption [17]. This can directly affect the food supply and logistics industry. The study of Tsolakis et al. [24] contended that using cryptographic proofs to verify the provenance and handling condition of fish can potentially disrupt the food certification industry by reducing the costs associated with audits and certifications. Although Luzzani et al. [34] identified no evidence of the use of BT in agri-food to monitor and reduce energy consumption, they further claimed that the use of BT facilitates increased transparency and traceability and results in reductions in cost in the supply chain. According to Stranieri et al. [31], adopting BT has resulted in economic benefits in terms of profits and/or returns on investment (ROIs). Specifically, the study found that an increase in profits can be observed at the supply chain level for the poultry and orange supply chains, which experienced a significant boost in sales. Additionally, the study revealed that the lemon supply chain improved ROIs, which was attributed to better production cost management, including reduced product loss and improved warehouse management. As per Ghode et al. [25], integrating BT in supply chain operations can minimize transaction costs compared with the conventional supply chain. This can be achieved by accurately forecasting demand, efficiently managing resources, and lowering inventory carrying costs.

4.2.3. Political Impact

The political impact focuses mainly on the government and policymakers relying more on product traceability and the transparency of agricultural processes in developing policies related to BT and the AFSC. Still, most blockchain implementation in the AFSC prioritizes these two terms [2]. Government projects have more complications than those of the private sectors in developing the right blockchain policies due to the bureaucratic system [12]. Thus, the government cannot establish proper policy regulations to achieve food integrity in the AFSC.

4.2.4. Technological Impact

Focusing on technological impact, the blockchain is the latest developed technology already being implemented in the agriculture industry. However, BT is not an accessible technology to be learnt in a short period due to the complexity of the system, meaning that farmers who are unfamiliar with the system cannot utilize it as they do not have much of the knowledge and skills needed to use the blockchain system [2]. It is also known that whatever information is uploaded to the blockchain system cannot be corrected [8]. Not selecting the right BT platform does not uniformly support supply chain management's strategic network control mechanisms [6]. Thus, food transparency and traceability have not been 100% achieved due to the technological impact and challenges supply chain members face. Adamashvili et al. [28] argued that the transparency of BT and its ability to track products throughout the entire supply chain provide an opportunity to identify contaminated products on time, allowing for the recall of only the hazardous items, rather than halting the whole production process. This approach reduces food waste and decreases transportation needs and the associated use of natural resources, which can significantly impact the environment. Tsolakis et al. [24] commented that by integrating all stakeholders, data, and technologies collaboratively, BT could facilitate comprehensive supply chain evaluation and consistently promote environmental sustainability. When integrated into wine sustainability certifications, programs, or standards, BT is also considered a tool for monitoring greenhouse gas emissions and water management [34].

4.2.5. Environmental Impact

BT's adoption by the program of ChainWood in Spain in the logistic industry aims to improve traceability and examine the forestry processions efficiently [46]. This project, however, has not brought environmental improvement in wood production. One probable reason is that BT has scalability issues, meaning that it cannot store vast amounts of data, which is exacerbated by the complexity of the environment's vast numbers of data transactions [36].

4.3. Blockchain Quantification

Blockchain quantification is a systematic approach to blockchain adoption. Blockchain quantification is essential to conciliate the impact of blockchain adoption in the AFSC and to access the utility of the conciliations [3]. Most studies quantifying the blockchain focus on China and Italy [31,47]. The European Union supports launching EU-wide rules to adopt the blockchain to prevent legal and regulatory issues [48]. Blockchain quantification can be summarized into two major categories, namely primary- and secondary-based data.

The first categorization of blockchain quantification across different countries and geography relies on secondary data [16]. Several studies have used simulations to quantify the blockchain [28]. Moreover, in secondary analyses, other methods were used to quantify the blockchain by using secondary blockchain databases [6,16,26,29], or the use of data from the literature [2,6,36]. The second categorization of blockchain quantification for the AFSC or a particular product relies more on primary data [37], blockchain collection and observation [9,30], or surveys and interviews [27,31,38,49]. The primary studies were more concerned with the ex ante and ex post of blockchain implementation. Scholars suggest that among all the methods used to implement blockchain technology in the AFSC, the collaboration of blockchain technology and the IoT can result in a sustainable implementation in AFSC operations [30,36,50]. Among all food categories, the dairy industries in the UK and Turkey [9,49], the wine industry in Europe [28], the fish industry in Thailand [24], the bacon meat industry in China [17], and the prawn industry in Australia [25] have started implementing blockchain technology.

4.4. Trade-Offs with BT Adoption in AFSC

A few articles have highlighted the significant trade-offs of BT adoption in the AFSC. These trade-offs were introduced to minimize and balance the challenges after adopting BT in the AFSC. Based on the literature, there were a few trade-offs found, such as the cost of BT adoption [8,17], intensified competition among suppliers [17], expanded market potential [17], tampered-with information [8], and product infection [8,17].

The cost of adopting BT in the agri-food supply chain is a significant trade-off that must be carefully considered. Implementing a blockchain-based system can be expensive, requiring considerable investment in hardware, software, and personnel [8]. Infrastructure costs can also increase, as BT requires significant computing power to operate effectively. Training personnel to use the technology and comply with regulatory requirements can also increase the overall cost of BT adoption. Additionally, ongoing maintenance costs can be high, mainly if the system is complex or requires significant customization. Despite these costs, stakeholders should consider the potential benefits of increased transparency, traceability, and accountability before deciding on BT adoption [17]. Careful consideration of the specific costs involved and their impact on the bottom line is necessary to make an informed decision.

The adoption of BT can also expand the market potential for suppliers. Suppliers can appeal to a broader range of customers with greater transparency, traceability, and accountability, increasingly demanding ethical and sustainable products [25]. However, expanding the market potential may also increase competition as more suppliers enter. This competition may drive prices and reduce profit margins, lowering supplier revenues [17]. Adopting BT in the agri-food supply chain can help prevent tampering with information and product infection, but it also involves significant trade-offs. While BT provides increased transparency and traceability, it is not entirely immune to tampering or hacking [8]. Hackers may manipulate data stored on the blockchain, reducing trust in the technology and damaging its credibility.

Furthermore, inaccurate information entered into the system could lead to the wrong products being identified as the source of an outbreak, resulting in unnecessary recalls and reputational damage [8]. Implementing a BT-based system can also be expensive, with infrastructure and ongoing maintenance costs adding up, which may outweigh the benefits of improved traceability and accountability. Finally, storing a large amount of data raises privacy concerns, despite the technology being designed to protect users' privacy [17]. Balancing the benefits of increased transparency and traceability with the potential costs of tampered-with information and product infection is essential for successfully adopting BT in the agri-food supply chain.

4.5. Use of Digital Technologies

Lately, digital tools such as smart contracts, IoT devices, and HACCP have become viable solutions for the impact of blockchain adoption in the AFSC [7,32] However, a limited amount of prior literature has contributed to understanding how these technologies can ease the performance of the AFSC by collaborating with the blockchain [7,31,32]. Stranieri et al. [31] argue that these technologies can improve efficiency, responsiveness, flexibility, transparency, and food quality in the AFSC. The traditional linear food movements between AFSC stakeholders can dissolve using digital platforms to facilitate food networks [51]. For instance, Tian (2017) proposed a food traceability system combining blockchain technology and the IoT to deliver the actual time condition of the food to SC members. Blockchain technology, smart contracts, and the IoT can be connected **to** be used in AFSC operations and enhance trust among the members of the AFSC [30]. The process of goods being transferred from producers to consumers should involve collaboration with BT and HACCP to track the food quality, temperature, humidity, and information, which was applied by Deloitte 2017 [52] for their dairy sector [32]. Furthermore, the study of Adamashvili, et al. [28] noted that BT greatly simplifies information sharing among supply chain actors. It digitizes processes, allowing for efficient tracking and tracing of products at a much lower cost and in a significantly shorter time. This can lead to improved productivity and cost-effectiveness, making it an attractive option for businesses operating in the supply chain.

4.6. Solutions to Mitigate Challenges after BT Adoption

Scholars have emphasized several strategies to minimize the impact after BT adoption [11,17,25–28,30,31,36]. Scholars should cater to the technical, organizational, and regulatory aspects [3]. These studies' strategies are broadly representable as behavioral, operational, and financial.

4.6.1. Behavioral Strategies

A linkage between behavioral strategies and BT adoption behavior was observable from the review of the existing literature. Through a qualitative study on individual user behavior in BT in the AFSC, Kramer et al. [6] developed a model to understand the factors influencing behavioral intentions towards using technology and BT. Stranieri et al. [31] have proposed an integrated conceptual framework using flexibility, efficiency, transparency, responsiveness, and food quality as performance dimensions to reduce the challenges after BT adoption while improving behavioral uncertainty among AFSC members.

4.6.2. Operational Strategies

BT adoption mainly focuses on transparency and immutability, traceability, interoperability, integration, transparency, visibility, disintermediation, decentralization, consensus mechanisms, and smart contracts that can improve the operational performance of the AFSC [26]. The other essential solution focusing on reducing the impact of BT adoption is analyzing suitable BT platforms for focal firms to coordinate AFSC activities using a vertical ecosystem that leads to smooth operations in the AFSC [6]. Adamashvili et al. [28] developed agent-based models to reduce operational costs and minimize latency after adopting BT. After observing platforms and suppliers that adopted BT, a game-theoretic model was developed by Yang et al. [8] with a focus on operational decision making in the AFSC.

4.6.3. Financial Strategies

The extant literature focuses on the reduction of impact after BT adoption in the AFSC by stabilizing the adoption cost for BT as farmers are not being paid accordingly, increased retail prices by processors [30], and increases in cost in BT adoption [17,36]. Since BT adoption increases cost, Dehghani et al. [27] posited a blockchain cloud solution to reduce the adoption cost of BT. In a similar stratum, narrowly defining the reduction of impact after BT adoption concerning economic criteria is daunting based on the far-reaching consequences of reducing the cost of BT adoption, as the knowledge of BT is still scarce. Thus, mitigating the impact after BT adoption can be enhanced if small and medium enterprises (SMEs) and industry practitioners devise a rational plan to improve the financial strategy for BT adoption in the AFSC [25].

4.7. BT towards Sustainable Development Goals (SDGs)

In addition to the benefits of nonexclusive traceability, immutability, and trust, BT contributes to sustainability performance and promotes the achievement of Sustainable Development Goals (SDGs) [24]. A quarter of greenhouse gas (GHG) is from the contribution of the AFSC globally [36,53]. Food waste generation, soil erosion, and abuse of resources are significant negative impacts of the AFSC [54]. Thus, researchers have focused on the effects on sustainability in the AFSC after BT adoption that leads to SDGs. The literature in this area represents three significant categories, as discussed below.

4.7.1. Socioenvironmental Impact

An extensive stream of research emphasizes the importance of analyzing the effects of socioenvironmental factors to provide sustainable products and information about the origin and quality of food [29,36,40]. For example, Heinrich et al. [40] reported that producing high-value botanic products can allow supply chain members to certify and guarantee against contaminated products. The adoption of BT has enabled consumers to track the origin of their food, which also contributes to the environment and social impact [4]. An emerging focus has developed, especially in the fish industry [24,36,55,56]. Kohler et al. [29] explained how blockchain-based technologies could be adopted in the AFSC and positively affect society and the environment. According to Rana et al. [36], BT can increase transparency in the agri-food sector and facilitate the delivery of high-quality foods while reducing social and environmental impacts. By utilizing the blockchain, supply chains can be made more visible, ensuring that consumers can access accurate information about the origin and quality of the food they purchase. This can have a positive impact on both industry and society as a whole.

4.7.2. BT Supported by Information and Communication Technology

Several studies have been examined by combining information and communication technology (ICT) with BT to explore the sustainability improvements achieved in the AFSC [24,29,36]. Alonso et al. [57] illustrated that combining technologies leads to sustainable information such as product quality and origin for consumers and process optimization for producers. Implementing ICT-Blockchain can increase food production sustainability [36,50,58], as BT enables the tracking of food loss or waste [36]. The Poseidon Foundation used blockchain-based mobile apps to promote sustainable forest management and degradation [46,59].

4.7.3. Research and Development

Tsolakis et al. [24] have performed research presenting an integrated technology implementation framework and four design principles by justifying that the presence of data asymmetry can promote SDGs. Mangla et al. [9] explained that critical traceability points being evaluated under BT could also contribute to SDGs, promoting food safety, well-being, and good health for everyone. Rana et al. [36] have mainly focused on the sustainability of the AFSC using BT and have argued that many current challenges must be addressed for sustainability in food production.

4.8. Other Emerging Themes

Three significant themes related to BT adoption have emerged in recent literature. These articles are on corporate social responsibility (CSR) [6,41,42], market expansion [9,17,43], and product resilience [16,24,43]. Kramer et al. [11] have developed a technology adoption model to study the impact of BT usage behavior for managers to establish a CSR strategy to bring positive outcomes on BT investments. Similarly, Sert et al. [42] have studied how CSR is linked to operational performance in the FSC. Mangla et al. [9] have provided an assumption that the number of partners collaborating in the dairy industry in Turkey is estimated to increase to around 2800 by 2025, which clearly shows potential for network expansion. Technology stakeholders in the United States' fresh produce industry also have seen a potential expectation of network expansion [43], as have those in the China industry [17]. Collart et al. [43] have also assessed production resilience in the AFSC industry with BT adoption. For instance, the strength of fishery systems in Thailand can also be improved through BT adoption [24].

5. Potential Research Gaps and Questions

After carefully assessing the extant literature, the authors identified potential research gaps. The research gaps were mapped using the themes developed from the literature review. Table 5 presents the possible research questions and research gaps for future researchers and practitioners. Regarding the BT adoption factors, there are a few gaps identified, such as the driver of BT adoption; this paper addressed what should be empirically tested in various cultural settings and using different methodologies by solving questions such as the following: What are the most critical drivers of BT adoption? What are the role and nature of internal quality standards after BT adoption? The second category, "Impact of BT Adoption in AFSC", points out the limited research on the logistics and operational effects of BT adoption and the lack of studies on BT adoption quality management. The potential research questions revolve around understanding how BT adoption affects the operational performance and logistics of the AFSC and how a quality management system can be utilized after BT adoption. The third category, "Blockchain Quantification", highlights gaps such as the absence of socioenvironmental costing in the overall cost of BT adoption and the lack of research on the impact of BT adoption in developing countries. The potential research topics include exploring a comprehensive study of the social, economic, and environmental aspects of costing in BT adoption, analyzing the differential effects of BT adoption in developed and developing countries, and addressing the challenges of implementing BT quantification.

Table 5. Theme-based research gaps and research questions.

Theme	Gaps	Potential Research Questions (RQs)
Factors of BT adoption	1. The drivers of BT adoption need to be assessed comprehensively, focusing mainly on the AFSC stage. 2. Lack of theory-driven research in BT adoption domain factors. 3. Studies on certain types of covenants for BT adoption roles are still scarce. 4. BT's adoptions towards internal quality standards for AFSC members remain unexplored.	1. What are the most critical drivers of BT adoption? 2. How do factors affect different stages of AFSC after BT adoption? 3. How is the impact of these factors quantified? 4. What is the role of internal quality standards after BT adoption? 5. What is the nature of these quality standards adopted in AFSC after BT adoption?
Impact of BT adoption in AFSC	1. Limited number of studies on logistics and operational effects after BT adoption. 2. Limited amount of research on BT adoption quality management.	1. How does BT adoption affect the operational performance of AFSC? 2. How can logistics performance be analyzed after BT adoption? 3. How can a quality management system be utilized after BT adoption?
Blockchain quantification	1. The overall cost of BT adoption does not involve socioenvironmental costing. 2. Irregular BT adoption quantification methods. 3. Lack of research on the impact of BT adoption in developing countries. 4. BT adoption has not been figured constantly in most studies. 5. More studies on BT adoption are needed at the production level as this is the first stage in AFSC.	1. Can the current research guide potential managers to perform a comprehensive study on the social, economic, and environmental aspects of costing in BT adoption? 2. How does BT adoption differently affect developed and developing countries? 3. What are the challenges of implementing BT quantification using an affiliated approach? 4. How can farmers overcome the challenges of BT adoption at the farm level? 5. How can society acknowledge BT adoption?

Table 5. *Cont.*

Theme	Gaps	Potential Research Questions (RQs)
The trade-off of BT adoption	1. Limited research has been performed on solutions to mitigate challenges after BT adoption and the trade-off.	1. What drivers should be achieved to connect the trade-off with BT management strategies?
Use of digital technologies	1. Lack of studies explaining the benefits and improvement of BT adoption after combination with digitalization. 2. Technology development combined with BT adoption has not geographically connected with the AFSC stage. 3. Future researchers must develop inexpensive digitalization tools that can be utilized through all AFSC stages. 4. Industry 5.0 has started to be studied by a few researchers to understand how this industry can benefit from BT adoption.	1. What are the benefits and improvements of digitalization in AFSC? 2. How does digitalization vary in AFSC stages and geographically? 3. Which is the most effective cost-saving tool that can be used in BT adoption? 4. What are the advantages and disadvantages of Industry 5.0 after combining with BT in AFSC?
The solution to mitigate challenges after BT adoption	1. Awareness campaigns on BT adoption have not been explored in recent literature. 2. Various studies on practical applicability are critical towards the challenges after BT adoption. 3. Lack of theories related to BT adoption. 4. Limited number of studies on policy research based on evidence for challenges after BT adoption measures.	1. How effective are awareness campaigns on the challenges of BT adoption mitigation? 2. To what extent are the solutions suggested in recent literature practically applicable to the challenges after BT adoption? 3. What contextual variables are involved based on reducing challenges in BT adoption? 4. How do these contingency theories quantify this effect? 5. How does policy intervention influence the AFSC stages?
BT towards SDGs	1. Limited number of studies on how BT adoption leads to the circular economy. 2. There is a lack of studies on how BT adoption models help mitigate the challenges after BT adoption and digital technologies. 3. Limited focus on implementation strategies to improve the performance in AFSC after BT adoption.	1. How does BT adoption lead to the circular economy? 2. How can BT adoption models help mitigate the challenges after adoption along with digital technologies? 3. Which are the potential strategies that can be implemented to improve the performance of AFSC after BT adoption?
Other emerging themes	1. Studies on CSR activities related to BT adoption are still scarce.	1. What potential CSR activities can be implemented to inspire BT adoption?

The fourth category, “The Trade-off of BT Adoption”, brings attention to the limited research on solutions to mitigate challenges after BT adoption and the trade-off. The potential research question emphasizes identifying the drivers that can connect the trade-off with BT management strategies. Likewise, the fifth category, “Use of Digital Technologies”, highlights the lack of studies explaining the benefits and improvements of BT adoption combined with digitalization and the need for inexpensive digitalization tools applicable across all AFSC stages. The potential research questions involve exploring the benefits and improvements of digitalization in the AFSC, understanding the geographic and stage-based variations of digitalization, and evaluating the advantages and disadvantages of Industry 5.0 combined with BT in the AFSC.

The sixth category, "The Solution to Mitigate Challenges after BT Adoption", addresses gaps such as the lack of awareness campaigns and theoretical frameworks related to BT adoption, as well as the limited number of studies on policy research for postadoption challenges. The potential research questions focus on assessing the effectiveness of awareness campaigns, evaluating the practical applicability of suggested solutions, understanding contextual variables influencing challenges in BT adoption, and examining the impact of policy interventions. The seventh category, "BT Towards SDGs", highlights the limited number of studies on how BT adoption contributes to the circular economy, the role of BT adoption models in mitigating postadoption challenges, and the need for implementation strategies to improve AFSC performance after BT adoption. The potential research questions aim to understand the relationship between BT adoption and the circular economy, explore the role of BT adoption models in overcoming challenges with digital technologies, and identify effective strategies to enhance AFSC performance. Finally, the table mentions the scarcity of studies on corporate social responsibility (CSR) activities related to BT adoption. The potential research question revolves around identifying potential CSR activities that can inspire BT adoption. However, these gaps and questions highlight areas where further research is needed to deepen our understanding of the impact, challenges, and potential solutions associated with BT adoption in the agricultural and food supply chain.

6. Implications of the Study

The present study has provided critical theoretical and practical implications. Several review studies have investigated the impact of BT adoption in the AFSC and mainly focused on events prior to adoption. The present research has advanced the extant literature and explored the critical areas after BT adoption in the AFSC.

This study has systematically gathered knowledge within highlighted areas using scholarly attention deficiency by conducting a thematic analysis. The analysis showed that the recent literature on the impact of BT adoption in the AFSC leads to the factors responsible for the effects after BT adoption in the AFSC. The thematic analysis approach used in this study will be a foundation for future researchers to explore and extend their scope by considering the development of digitalization and the circular economy for the challenges after BT adoption mitigation in the AFSC. Furthermore, analyzing themes and research profiling in the literature rejuvenate scholars' understanding concerning the issues associated with BT adoption. Focusing on and highlighting the themes, such as solutions to mitigate the challenges after BT adoption in the AFSC, BT quantification, and factors responsible for the impact after BT adoption in the AFSC, led to the study pathway and contributes to the global agenda for solutions to mitigate BT adoption in the AFSC. Using a research profiling approach, the SLR points were gathered based on geographic location, AFSC stages, and product groups.

This study identifies the potential research questions and research gaps to mitigate these gaps by pointing out some critical research questions. Thus, this work has contributed to future research agendas. The recent SLR divulges future studies that should be considered while evaluating the impact of BT adoption in the AFSC. The effect should be analyzed in terms of the socioenvironmental factors as well. The present study highlights the need to shift attention towards focusing on the impact after BT adoption. Finally, this study provides a systematic summary of the impact after BT adoption and constructs an action plan to offer solutions to mitigate the effects after BT adoption.

The present study has provided six dominant implications for practitioners associated with the AFSC. Producers should understand the problems developed after BT adoption in the AFSC as their tasks and responsibilities play a vital role in BT adoption in the AFSC. The critical points for practitioners are summarized below.

The thematic foci presented in this study can help producers and all the members of the AFSC to have a worm's eye view of the scope and depth of the issues associated with BT adoption in the AFSC. For instance, there is evidence from the literature that the adoption of the blockchain causes incentive conflict between local suppliers and overseas suppliers due to a higher procurement price that affects the market share and profit margin due to the high cost of blockchain adoption [17]. Next, the method of quantifying BT adoption needs attention. The literature states that BT quantification logs their data using several methods. Proper guidelines need to be developed to assist the AFSC members with accurate BT quantification focusing on the magnitude of the problem. Additionally, the exaggeration of the monetary value of BT adoption needs to be exchanged with a BT quantification strategy that includes socioenvironmental impacts.

AFSC members need to understand the importance of digital technologies for managing and mitigating BT adoption. Digitalization principles can help minimize the impact of BT adoption in the AFSC [31]. Furthermore, producers such as farmers who acknowledge the importance of BT adoption in the AFSC must learn and support the development of infrastructure on new technologies such as the IoT, which helps smoothen the data tracking process in the AFSC. This is necessary for businesses as, in the future, most of the food business will be driven by data, which might exclude those not used to this technological development. Despite that, most empirical studies focus on BT adoption drivers regarding AFSC stages, product categories, and geographic location. To hypothesize the findings, all AFSC members should uphold their studies with their input. Verification from the AFSC members will highlight any potential deficiencies, if there are any, with the theoretical findings that the recent literature offers.

The subsequent implication that AFSC members should understand is the impact of BT adoption in the AFSC. The studies on BT adoption with sustainability highlight the effect after BT adoption in the AFSC that can be achieved by focusing on SDGs [24,36]. Achieving sustainability using BT adoption in the AFSC can guide the AFSC members to manage resources efficiently. By adopting the solution to mitigate the impact after BT adoption in the AFSC, this study can guide AFSC members towards understanding the importance of allocating resources efficiently. The final implication can provide policymakers with ideas and guidelines to devise policy mediation for BT adoption issues. Policymakers also play a dominant role in several cases. As is evident from the literature, policymakers rely more on product traceability and the transparency of agricultural processes in developing policies related to BT and the AFSC. However, most of the blockchain implementation in the AFSC prioritizes these two terms [2]. Policymakers should also focus on components such as product resilience and sustainability with BT adoption. The findings have provided a pathway for them to perform a reality check starting from ground-level conditions rather than focusing more on product traceability and transparency.

7. Conclusions, Limitations, and Suggestions for Future Studies

The present SLR involved critical research on the impact of BT adoption in the AFSC. This study makes diverse contributions to the contemporary literature. As for the first contribution, the theory, the SLR used the existing research and carefully organized the key contributors, countries of origin, publication timelines, and 27 articles. The analysis disseminates that the research in this area has remained chiefly scattered. The literature on the impact after BT adoption in the AFSC overlaps the domain of researchers, the level of analysis, and various methodologies, and expands across multiple journals. The earlier reviewed studies focused more on the ex ante of BT adoption and presented BT adoption in the AFSC, and the main focus was on the AFSC stages. However, the present study demonstrated a detailed literature analysis and gathered dominant themes in their entirety. Thus, the second contribution is dividing the literature based on the key terms that led to recognizing the crucial topics for BT adoption research. The following are the key themes: (a) the factors of BT adoption; (b) the impact after BT adoption in the AFSC; (c) blockchain quantification; (d) the trade-offs of BT adoption; (e) the use of digital technologies; (f) solutions to mitigate challenges after BT adoption in the AFSC; (g) BT moving towards SDGs; and (h) other emerging themes. Based on the literature analysis, the factors responsible for BT adoption in the AFSC are food traceability and transparency, food safety and security, food supply and logistics, food integrity, and food waste and environmental awareness. The present SLR also has presented the solution to mitigate challenges after BT adoption in the AFSC from the literature. The final contribution of the SLR is that the review was concluded by delineating the gaps and potential research questions to guide future researchers and framework development.

This review has elucidated the state of BT adoption in AFSC research. However, there are limitations that future researchers can take up to review or study. First, the authors only focused on English journals on the Web of Science (WOS) database. Therefore, some appurtenant studies were possibly missing from the present SLR. Future SLRs can also explore journals in other languages, proceedings papers, and book chapters by using different databases. Furthermore, we have focused on article selection using the inclusion and exclusion approach and excluded conceptual studies. This scope and study would have completed the recent review but were excluded due to scope constraints. Last but not least, the scope for the digitalization of technologies and sustainability combined with BT adoption is embryonic. Nevertheless, future researchers would have used these studies as guidance for future studies. However, with the expansion of the digitalization era, some of the findings may be useful in the future. Even so, this research has provided information on the emerging themes of BT adoption for future literature. Henceforward, it would be constructive to carry out a bibliometric study to provide a deeper understanding of the impact after BT adoption in the AFSC by comparing the development of BT adoption in other countries. The authors hope the present study can be helpful for future researchers and practitioners to explore more in this area.

Author Contributions: Conceptualization, M.H.A. and L.H.O.; methodology, L.Y.; formal analysis, L.Y. and M.M.; data curation, L.Y. and S.S.A.; writing—original draft preparation, L.Y., M.M. and S.S.A.; writing—review and editing, M.H.A., N.K. and L.H.O.; supervision, M.H.A. and L.H.O.; project administration, M.H.A.; funding acquisition, M.H.A., L.H.O. and N.K. All authors have read and agreed to the published version of the manuscript.

Funding: The authors acknowledge the Fundamental Research Grants Scheme (FRGS), grant number FRGS/1/2021/SS01/UKM/02/1 funded by Ministry of Higher Education (MOHE), Malaysia, and the part of this research is supported by EP-2020-028 funded by MPOB-UKM.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Hew, J.-J.; Wong, L.-W.; Tan, G.W.-H.; Ooi, K.-B.; Lin, B. The blockchain-based Halal traceability systems: A hype or reality? *Supply Chain Manag. Int. J.* **2020**, *25*, 863–879. [CrossRef]
2. Mavilia, R.; Pisani, R. Blockchain for agricultural sector: The case of South Africa. *Afr. J. Sci. Technol. Innov. Dev.* **2021**, *14*, 845–851. [CrossRef]
3. Rejeb, A.; Keogh, J.G.; Zailani, S.; Treiblmaier, H.; Rejeb, K. Blockchain Technology in the Food Industry: A Review of Potentials, Challenges and Future Research Directions. *Logistics* **2020**, *4*, 27. [CrossRef]
4. Munir, M.A.; Habib, M.S.; Hussain, A.; Shahbaz, M.A.; Qamar, A.; Masood, T.; Sultan, M.; Mujtaba, M.A.; Imran, S.; Hasan, M.; et al. Blockchain Adoption for Sustainable Supply Chain Management: Economic, Environmental, and Social Perspectives. *Front. Energy Res.* **2022**, *10*, 899632. [CrossRef]
5. Ali, M.H.; Chung, L.; Kumar, A.; Zailani, S.; Tan, K.H. A Sustainable Blockchain Framework for the Halal Food Supply Chain: Lessons from Malaysia. *Technol. Forecast. Soc. Chang.* **2021**, *170*, 120870. [CrossRef]
6. Kramer, M.P.; Bitsch, L.; Hanf, J. Blockchain and Its Impacts on Agri-Food Supply Chain Network Management. *Sustainability* **2021**, *13*, 2168. [CrossRef]
7. Kamilaris, A.; Fonts, A.; Prenafeta-Boldύ, F.X. The rise of blockchain technology in agriculture and food supply chains. *Trends Food Sci. Technol.* **2019**, *91*, 640–652. [CrossRef]
8. Yang, L.; Zhang, J.; Shi, X. Can blockchain help food supply chains with platform operations during the COVID-19 outbreak? *Electron. Commer. Res. Appl.* **2021**, *49*, 101093. [CrossRef]
9. Mangla, S.K.; Kazancoglu, Y.; Ekinci, E.; Liu, M.; Özbiltekin, M.; Sezer, M.D. Using system dynamics to analyze the societal impacts of blockchain technology in milk supply chainsrefer. *Transp. Res. Part E Logist. Transp. Rev.* **2021**, *149*, 102289. [CrossRef]

10. Denyer, D.; Tranfield, D. Producing a Systematic Review. In *The SAGE Handbook of Organizational Research Methods*; Sage Publications Ltd.: Newbury Park, CA, USA, 2009.
11. Kramer, M.P.; Bitsch, L.; Hanf, J.H. The Impact of Instrumental Stakeholder Management on Blockchain Technology Adoption Behavior in Agri-Food Supply Chains. *J. Risk Financ. Manag.* **2021**, *14*, 598. [CrossRef]
12. Vadgama, N.; Tasca, P. An Analysis of Blockchain Adoption in Supply Chains Between 2010 and 2020. *Front. Blockchain* **2021**, *4*, 610476. [CrossRef]
13. Yu, W.; Chavez, R.; Jacobs, M.A.; Feng, M. Data-driven supply chain capabilities and performance: A resource-based view. *Transp. Res. Part E Logist. Transp. Rev.* **2018**, *114*, 371–385. [CrossRef]
14. Göbel, C.; Langen, N.; Blumenthal, A.; Teitscheid, P.; Ritter, G. Cutting Food Waste through Cooperation along the Food Supply Chain. *Sustainability* **2015**, *7*, 1429–1445. [CrossRef]
15. Porter, S.D.; Reay, D.S.; Higgins, P.; Bomberg, E. A Half-Century of Production-Phase Greenhouse Gas Emissions from Food Loss & Waste in the Global Food Supply Chain. *Sci. Total Environ.* **2016**, *571*, 721–729. [CrossRef]
16. Bayramova, A.; Edwards, D.J.; Roberts, C. The Role of Blockchain Technology in Augmenting Supply Chain Resilience to Cybercrime. *Buildings* **2021**, *11*, 283. [CrossRef]
17. Niu, B.; Dong, J.; Dai, Z.; Jin, J.Y. Market expansion vs. intensified competition: Overseas supplier's adoption of blockchain in a cross-border agricultural supply chain. *Electron. Commer. Res. Appl.* **2021**, *51*, 101113. [CrossRef]
18. Rogers, E.M.; Ban, A.W.V.D. Research on the diffusion of agricultural innovations in the United States and the Netherlands. *Sociol. Rural.* **1963**, *3*, 38–49. [CrossRef]
19. Hayden, E.C. Technology: The $1000 genome. *Nature* **2014**, *507*, 294–295. [CrossRef]
20. Rogers, E.M. Diffusion of Innovations. In *BT—Diffusion of Innovations*, 5th ed.; Free Press: New York, NY, USA, 2003.
21. Tranfield, D.; Denyer, D.; Smart, P. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *Br. J. Manag.* **2003**, *14*, 207–222. [CrossRef]
22. Derwik, P.; Hellström, D. Competence in Supply Chain Management: A Systematic Review. *Supply Chain. Manag.* **2017**, *22*, 200–218. [CrossRef]
23. Bhat, S.A.; Huang, N.-F.; Sofi, I.B.; Sultan, M. Agriculture-Food Supply Chain Management Based on Blockchain and IoT: A Narrative on Enterprise Blockchain Interoperability. *Agriculture* **2021**, *12*, 40. [CrossRef]
24. Tsolakis, N.; Niedenzu, D.; Simonetto, M.; Dora, M.; Kumar, M. Supply network design to address United Nations Sustainable Development Goals: A case study of blockchain implementation in Thai fish industry. *J. Bus. Res.* **2020**, *131*, 495–519. [CrossRef]
25. Ghode, D.; Yadav, V.; Jain, R.; Soni, G. Adoption of Blockchain in Supply Chain: An Analysis of Influencing Factors. *J. Enterp. Inf. Manag.* **2020**, *33*, 437–456. [CrossRef]
26. Kayikci, Y.; Usar, D.D.; Aylak, B.L. Using blockchain technology to drive operational excellence in perishable food supply chains during outbreaks. *Int. J. Logist. Manag.* **2021**, *33*, 836–876. [CrossRef]
27. Dehghani, M.; Popova, A.; Gheitanchi, S. Factors impacting digital transformations of the food industry by adoption of blockchain technology. *J. Bus. Ind. Mark.* **2021**, *37*, 1818–1834. [CrossRef]
28. Adamashvili, N.; State, R.; Tricase, C.; Fiore, M. Blockchain-Based Wine Supply Chain for the Industry Advancement. *Sustainability* **2021**, *13*, 13070. [CrossRef]
29. Köhler, S.; Pizzol, M. Technology assessment of blockchain-based technologies in the food supply chain. *J. Clean. Prod.* **2020**, *269*, 122193. [CrossRef]
30. Pranto, T.H.; Noman, A.A.; Mahmud, A.; Haque, A.B. Blockchain and smart contract for IoT enabled smart agriculture. *PeerJ Comput. Sci.* **2021**, *7*, e407. [CrossRef]
31. Stranieri, S.; Riccardi, F.; Meuwissen, M.P.M.; Soregaroli, C. Exploring the Impact of Blockchain on the Performance of Agri-Food Supply Chains. *Food Control* **2021**, *119*, 107495. [CrossRef]
32. Kayikci, Y.; Subramanian, N.; Dora, M.; Bhatia, M.S. Food Supply Chain in the Era of Industry 4.0: Blockchain Technology Implementation Opportunities and Impediments from the Perspective of People, Process, Performance, and Technology. *Prod. Plan. Control* **2022**, *33*, 301–321. [CrossRef]
33. De Oliveira, M.P.V.; Handfield, R. Analytical foundations for development of real-time supply chain capabilities. *Int. J. Prod. Res.* **2019**, *57*, 1571–1589. [CrossRef]
34. Luzzani, G.; Grandis, E.; Frey, M.; Capri, E. Blockchain Technology in Wine Chain for Collecting and Addressing Sustainable Performance: An Exploratory Study. *Sustainability* **2021**, *13*, 12898. [CrossRef]
35. Steenmans, K.; Taylor, P.; Steenmans, I. Blockchain Technology for Governance of Plastic Waste Management: Where Are We? *Soc. Sci.* **2021**, *10*, 434. [CrossRef]
36. Rana, R.L.; Tricase, C.; De Cesare, L. Blockchain technology for a sustainable agri-food supply chain. *Br. Food J.* **2021**, *123*, 3471–3485. [CrossRef]
37. Kumar, S.; Velliangiri, S.; Karthikeyan, P.; Kumari, S.; Kumar, S.; Khan, M.K. A Survey on the Blockchain Techniques for the Internet of Vehicles Security. *Trans. Emerg. Telecommun. Technol.* **2021**, e4317. [CrossRef]
38. Garrard, R.; Fielke, S. Blockchain for trustworthy provenances: A case study in the Australian aquaculture industry. *Technol. Soc.* **2020**, *62*, 101298. [CrossRef]
39. Tian, F. A Supply Chain Traceability System for Food Safety Based on HACCP, Blockchain & Internet of Things. In Proceedings of the 14th International Conference on Services Systems and Services Management, ICSSSM 2017, Dalian, China, 16–18 June 2017.

40. Heinrich, M.; Scotti, F.; Booker, A.; Fitzgerald, M.; Kum, K.Y.; Löbel, K. Unblocking High-Value Botanical Value Chains: Is There a Role for Blockchain Systems? *Front. Pharmacol.* **2019**, *10*, 396. [CrossRef]
41. Moggi, S.; Bonomi, S.; Ricciardi, F. Against Food Waste: CSR for the Social and Environmental Impact through a Network-Based Organizational Model. *Sustainability* **2018**, *10*, 3515. [CrossRef]
42. Sert, S.; Garrone, P.; Melacini, M.; Perego, A. Corporate food donations: Altruism, strategy or cost saving? *Br. Food J.* **2018**, *120*, 1628–1642. [CrossRef]
43. Collart, A.J.; Canales, E. How might broad adoption of blockchain-based traceability impact the U.S. fresh produce supply chain? *Appl. Econ. Perspect. Policy* **2022**, *44*, 219–236. [CrossRef]
44. De Silva, M. European Grocer Carrefour Expands Blockchain for Supply Chain. Available online: https://zbhk.medium.com/zb-european-grocer-carrefour-expands-blockchain-for-supply-chain-210deb212980 (accessed on 12 April 2023).
45. Katz, D. Plastic Bank: Launching Social Plastic Revolution. *Field Actions Sci. Rep.* **2019**, *2019*, 96–99.
46. OECD; FAO. *OECD-FAO Agricultural Outlook 2019–2028*; OECD: Paris, France; FAO: Paris, France, 2020.
47. Fu, H.; Zhao, C.; Cheng, C.; Ma, H. Blockchain-Based Agri-Food Supply Chain Management: Case Study in China. *Int. Food Agribus. Manag. Rev.* **2020**, *23*, 667–679. [CrossRef]
48. Georgescu, B.; Onete, C.B.; Pleșea, D.A.; Chița, S.D.; Sava, S. Consumer Attitude towards the Use of Blockchain Technology. Study on the Implementation of the "Green Deal" Strategy for Organic Foods. *Amfiteatru Econ.* **2022**, *24*, 379–394. [CrossRef]
49. Mazzù, M.F.; Marozzo, V.; Baccelloni, A.; de'Pompeis, F. Measuring the Effect of Blockchain Extrinsic Cues on Consumers' Perceived Flavor and Healthiness: A Cross-Country Analysis. *Foods* **2021**, *10*, 1413. [CrossRef]
50. Li, J.; Maiti, A.; Springer, M.; Gray, T. Blockchain for supply chain quality management: Challenges and opportunities in context of open manufacturing and industrial internet of things. *Int. J. Comput. Integr. Manuf.* **2020**, *33*, 1321–1355. [CrossRef]
51. Harvey, J.; Smith, A.; Goulding, J.; Illodo, I.B. Food sharing, redistribution, and waste reduction via mobile applications: A social network analysis. *Ind. Mark. Manag.* **2020**, *88*, 437–448. [CrossRef]
52. Schatsky, D.; Piscini, E. Deloitte Survey: Blockchain Reaches beyond Financial Services with Some Industries Moving Faster. Deloit 2016. Available online: https://www2.deloitte.com/hr/en/pages/press/articles/blockchain-2017.html (accessed on 15 April 2023).
53. Principato, L.; Ruini, L.; Guidi, M.; Secondi, L. Adopting the circular economy approach on food loss and waste: The case of Italian pasta production. *Resour. Conserv. Recycl.* **2019**, *144*, 82–89. [CrossRef]
54. Cellura, M.; Longo, S.; Mistretta, M. Life Cycle Assessment (LCA) of protected crops: An Italian case study. *J. Clean. Prod.* **2012**, *28*, 56–62. [CrossRef]
55. Kshetri, N. 1 Blockchain's Roles in Meeting Key Supply Chain Management Objectives. *Int. J. Inf. Manag.* **2018**, *39*, 80–89. [CrossRef]
56. Blaha, F.; Kenneth, K. Blockchain Application in Seafood Value Chains. *FAO Fish. Aquac. Circ.* **2020**, *C1207*, I-43.
57. Munhoz, P.A.M.S.A.; Dias, F.D.C.; Chinelli, C.K.; Guedes, A.L.A.; dos Santos, J.A.N.; Silva, W.D.S.E.; Soares, C.A.P. Smart Mobility: The Main Drivers for Increasing the Intelligence of Urban Mobility. *Sustainability* **2020**, *12*, 10675. [CrossRef]
58. Chen, S.; Shi, R.; Ren, Z.; Yan, J.; Shi, Y.; Zhang, J. A Blockchain-Based Supply Chain Quality Management Framework. In Proceedings of the 14th IEEE International Conference on E-Business Engineering, ICEBE 2017, Shanghai, China, 4–6 November 2017.
59. Howson, P.; Oakes, S.; Baynham-Herd, Z.; Swords, J. Cryptocarbon: The Promises and Pitfalls of Forest Protection on a Blockchain. *Geoforum* **2019**, *100*, 1–9. [CrossRef]