logistics

MDPI

Article

Blockchain for Ecologically Embedded Coffee Supply Chains

Hana Trollman [1,*], Guillermo Garcia-Garcia [2], Sandeep Jagtap [3] and Frank Trollman [4]

1 Department of Work, Employment, Management and Organisations, School of Business, University of Leicester, Brookfield, 266 London Road, Leicester LE2 1RQ, UK
2 Department of Agrifood System Economics, Institute of Agricultural and Fisheries Research & Training (IFAPA), P.O. Box 2027, 18080 Granada, Spain; guillermo.garcia@juntadeandalucia.es
3 Sustainable Manufacturing Systems Centre, School of Aerospace, Transport and Manufacturing, Cranfield University, Cranfield MK43 0AL, UK; s.z.jagtap@cranfield.ac.uk
4 Glenfield Hospital, University Hospitals of Leicester, NHS Trust, Leicester LE3 9QP, UK; ftrollman@gmail.com
* Correspondence: ht203@leicester.ac.uk

Abstract: *Background*: This research aims to identify how blockchain technology could support the ecological embeddedness of the coffee supply chain. Ecological embeddedness is a subset of the circular economy (CE) that demands legitimacy through design changes to product, production and/or packaging for benefits to economic actors and the environment. This is in contrast with legitimacy as a public relations exercise. Blockchain is a digital transformation technology that is not fully conceptualized with respect to supply chain implementation and the related strategy formulation, particularly in the context of sustainability. Furthermore, the integration of consumers into the CE remains not well understood or researched, with the main focus of CE being the cycling of resources. *Methods*: This research employs a qualitative case study methodology of the first coffee business in the USA to use blockchain technology as an exemplar. Gap analysis is then applied to identify how blockchain could be used to advance from the current state to a more sustainable one. *Results*: Findings indicate that the implementation of blockchain is not ecologically embedded in the example studied. *Conclusions*: The extension of blockchain technology to consider the by-products of production and valorizable waste throughout the supply chain as assets would support ecologically embedded CE for coffee.

Keywords: blockchain; circular economy; coffee; ecological embeddedness; supply chain; sustainability

check for updates

Citation: Trollman, H.; Garcia-Garcia, G.; Jagtap, S.; Trollman, F. Blockchain for Ecologically Embedded Coffee Supply Chains. *Logistics* **2022**, *6*, 43. https://doi.org/10.3390/logistics6030043

Academic Editors: Herwig Winkler and Robert Handfield

Received: 20 May 2022
Accepted: 21 June 2022
Published: 24 June 2022

1. Introduction

Coffee is one of the world's most valuable traded commodities, making it a driving factor in the global economy. There are many sustainability concerns related to coffee production, including coffee farmers unable to earn a living income, child labour, ecological degradation, resource use, pollution and waste. Consequently, the sustainability of coffee production is of concern to conscientious consumers [1,2], the coffee industry, governments [3] and sustainability researchers [4].

Blockchain is a "shared, cryptographically unaltered distributed ledger" for recording and maintaining digital transaction history [5]. Blockchain has been recognized as a digital technology capable of adding an aspect of sustainability to supply chains that is correlated with the circular economy (CE) [6]. The notion of Blockchain for Good (B4G) yields innovative applications that may support socially and environmentally beneficial outcomes in terms of the UN's Sustainable Development Goals [7]. This has led some coffee producers and associated businesses to apply blockchain in their supply chains, and recent research encourages a wider adoption of this technology [8,9]. However, blockchain projects in the food sector are at a nascent stage, with a majority of applications limited to food traceability and safety [10,11]. With the consideration of B4G also come concerns about uses of blockchain that are not ecologically embedded or that lack legitimacy [12].

In this study, the perspective of ecological embeddedness is adopted to better understand the sustainability relationships in the coffee supply chain. Institutional theory is used to analyse the vertical relationships among smallholders, suppliers, the large buyer and consumers to identify where blockchain may intervene to improve CE and sustainability practices. Literature that considers multiple stages in the supply chain is relatively recent (e.g., [13–17]). Luo and Choi [18] advocate the use of real case studies for informing blockchain systems for practical business operations and sustainability whilst identifying critical success factors.

The theoretical lens of this study is the consumer experience, and the aim is to provide a nuanced understanding of the consumer aspects of legitimacy with respect to the ecological embeddedness of the case product [19]. Supply chain adoption of blockchain technology has as a first consideration the traceability awareness of consumers, which can be determined by investigating consumers' level of concern about product quality and safety as well as their willingness to pay for a traceable product [20]. The theoretical lens of consumer experience is combined with a qualitative (theory-building) approach that guides the investigation [21]. Consequently, this research focusses on the identification of unrealized benefits of blockchain adoption as part of the investigation of 'social' relations within the context of embeddedness [22]. As stated by Morris and Kirwan [22] "... to be understood as ecologically embedded ... a conscious or deliberate effort on the part of producers to communicate information about on-farm ecological relations must occur, either in person or through packaging or other promotional materials." Where information is not accessible from the consumer perspective, ecological embeddedness is lacking.

The first comprehensive study of the ecological embeddedness of supply chains was at a national level and in a regional case study for the Austrian food system with two conventional bread chains [23]. Subsequent research has predominantly focused on alternative, local and green supply chains which continue to be of interest (e.g., [24–27]). Globalization is increasingly considered along with the restructuring of agricultural value chains to reconnect supply chains and ecosystems at territory level, identifying a gap for reaching operational effectiveness in the lack of integration between biophysical and socioeconomic approaches [28,29]. Empirical findings indicate that perceived fairness has a highly positive link with embeddedness and that both embeddedness and knowledge sharing is significant to green innovation in sustainable supply chains [30]. However, the importance of technology in enabling ecological embeddedness is rarely considered or analyzed [31] and how blockchain could specifically support the ecological embeddedness of supply chains has yet to be fully considered [32]. There is a general lack of published case studies and concrete examples of the use of blockchain technology [33]. This study addresses this gap by investigating the potential contributions of blockchain to the ecological embeddedness of global supply chains using a case exemplar. The unique contribution of this work is the identification of blockchain as a technological enabler of ecologically embedded coffee supply chains.

The aim of this research is to study the blockchain application in a coffee supply chain to investigate how well sustainability and CE issues are addressed by the addition of this technology. Gap analysis and case knowledge are then employed to make recommendations for improvement.

The remainder of this paper is structured as follows. The first section presents a brief review of the literature related to CE, ecological embeddedness, and blockchain. This is followed by the methodology, that highlights why the case was selected and the approach to data analysis. Next, the results of the study are presented followed by a discussion of the results and their implications.

2. Literature Review

2.1. CE Theory Applied to Coffee

CE is distinguished from the linear economy by its inclusion of biological and technical loops that aim to slow, close or narrow the cycling of resources [34]. Slowing is achieved through the design of longer-lasting products and extending product life through maintenance and repair. Narrowing loops are a form of resource efficiency that reduce the cost of production. Closing loops implement recycling between post-use and production for a circular flow of resources. By extension, CE may be similarly applied to the packaging of a product, although the complex assessment of packaging in relation to particular products is only beginning to be investigated [35].

Coffee is grown in over 70 countries with ideal conditions along the equatorial zone between latitudes 25 degrees north and 30 degrees south. This means that delivery to many countries requires long transports of the beans for further processing (narrowing CE loops) and ideally reusable and/or recyclable packaging (slowing/closing loops). Coffee production generates considerable amounts of solid waste (by-products) such as defective green coffee beans, coffee tree leaves and coffee cherry husks as well as wastewater [36], uses resources in terms of energy and water principally, and generates consumer waste as spent coffee grounds. Many applications of coffee waste have been proposed as part of a CE including substrate for agricultural production, conversion into fuel, use as biosorbent for removal of pollutants from wastewater, and the extraction of value-added compounds such as antioxidants and dietary fibres [36–38].

2.2. Blockchain Capabilities in Support of CE

Blockchain is a combination of technologies with components such as public/private key cryptography [39], cryptographic hash functions [40], database technologies (distributed databases), consensus algorithms [41], and decentralized processing. These relate to the technical choices of implementing a blockchain, including permission design, choice of consensus algorithm, use of smart contracts, and use of cryptocurrency. The proper management of information throughout the blockchain may benefit strategic decisions related to natural resources and raw materials in support of CE [42]. Innovation in blockchain architectures, applications and business concepts is ongoing.

However, the implementation of blockchain needs to be technically supported and the benefits clearly identified [5,43]. The main challenge for blockchain is trust: ensuring that counterfeit blocks or counterfeit data do not permeate transactions that may then corrupt the digital ecosystem [44].

Blockchain features such as transparency, traceability, smart contracts, decentralization, data immutability and data privacy together with consensus mechanisms make blockchain suitable for complex supply chains with the potential to improve sustainability and resilience [6,45,46]. The tracking and sharing of data related to the environmental and social aspects of sustainability may reduce the related issues around food safety, intermediaries and transaction costs while building trust between producers and consumers [7,47].

2.3. Ecological Embeddedness Theory and Blockchain

Ecological embeddedness is a subset of the circular economy that demands legitimacy through design changes to product, production and/or packaging [12]. Ecological embeddedness is more comprehensible for companies when compared to the discursive paradigms that are “sustainability” and “sustainable development” and related concepts such as “embedding sustainability” [48]: ecological embeddedness simply requires that both the economic actors and the environment benefit [22]. Benefits may take the form of cost savings, health benefits or customer loyalty benefits (related to trust) [12]. For example, reducing waste in the supply chain benefits the environment as less waste needs to be absorbed, and the economic actors also benefit from the decrease in costs associated with losses due to waste as long as these savings are shared throughout the supply chain. Sharing benefits among all supply chain actors has been linked to significant supernormal profit (when total revenue exceeds total cost) and suggests that manufacturers centrally positioned in triadic supply chains should deliberately shape relational embeddedness with suppliers and customers [49].

Ecological embeddedness enforces a holistic perspective on sustainability-related changes including the implementation of digital transformational technology such as blockchain through the necessary consideration of impacts on both economic actors and the environment. Blockchain has been examined as a dynamic capability that is perceived to improve both external (suppliers and customers) competencies and internal integration; however, the focus was only on the economic component with further studies recommended for environmental and social sustainable supply chain performance [50]. Ecological embeddedness relates to blockchain technology through economic, social and environmental considerations: Among the most basic questions to ask when investigating implementation is "Who benefits?", alongside "What problems does blockchain solve?" and "What problems does blockchain create?" [51].

Such questions are more likely to be realistically addressed when real-world applications are investigated. Having built the theoretical structure for this study, there is evident value in investigating the hypothesis that ecologically embedded blockchain enables CE and sustainability in the coffee supply chain as described in the following section.

2.4. Blockchain Impacts on Business Performance

One specific focus of blockchain research has been supply chains as the "most promising non-finance application of blockchain" believed "to deliver real Return on Investment at an early state of blockchain development" [52]. Blockchain technology aids the authentication of products, facilitates disintermediation and improves operational efficiency [53]. Blockchain technology reduces risks, which could negatively affect company performance related to the clarity of supply sources, counterfeit and poor-quality products and fraud in contract fulfilment while providing the flexibility of capacity and sensitivity to demand change [54]. However, blockchain companies are not delivering the promised business value precipitated by a lack of understanding of how blockchain technology may benefit their respective business models [55,56].

The performance of a supply chain needs to be driven by management initiatives. The value placed on an initiative such as blockchain may originate with stakeholders and retailers to create added value for customers and improve company and supply chain performance [57–60]. Masudin et al. [61] demonstrated that implementing green supply chain management practices has positive and significant impacts on performance. Managerial initiatives have been found to support traceability system adoption, which significantly and positively affects food cold chain performance [62]. Consequently, the investigation of blockchain implementation for supporting ecologically embedded coffee supply chains in this research is justified.

3. Methodology

A qualitative case-study approach has been chosen to explore the relevant relations of ecological embeddedness and hence an in-depth approach is required [63,64]. Case-study research is a suitable research strategy for the food sector as it enables investigations of ecological embeddedness [23,30,65]. Ecological embeddedness remains under-investigated in sustainable supply chains [66], and the case study method fits the exploration of this complex phenomenon. A case study enables the capture of both situational and context-specific factors regarding the connectedness and embeddedness of relationships that may then be related to the role of blockchain as an exploratory investigation [67]. The research process flow is based on a case study approach [68] as shown in Figure 1.

A single-case design may be conducted if an extreme or unusual case is chosen and if rarely observed phenomena are investigated to better understand the underlying relationships [69]. The selected case research design aims to understand the meaning-making behind the legitimacy of technology application under institutional theory. The intrinsic case shapes the direction of the case study by offering thick descriptions (observation, description, interpretation and analysis of the situation) [70].

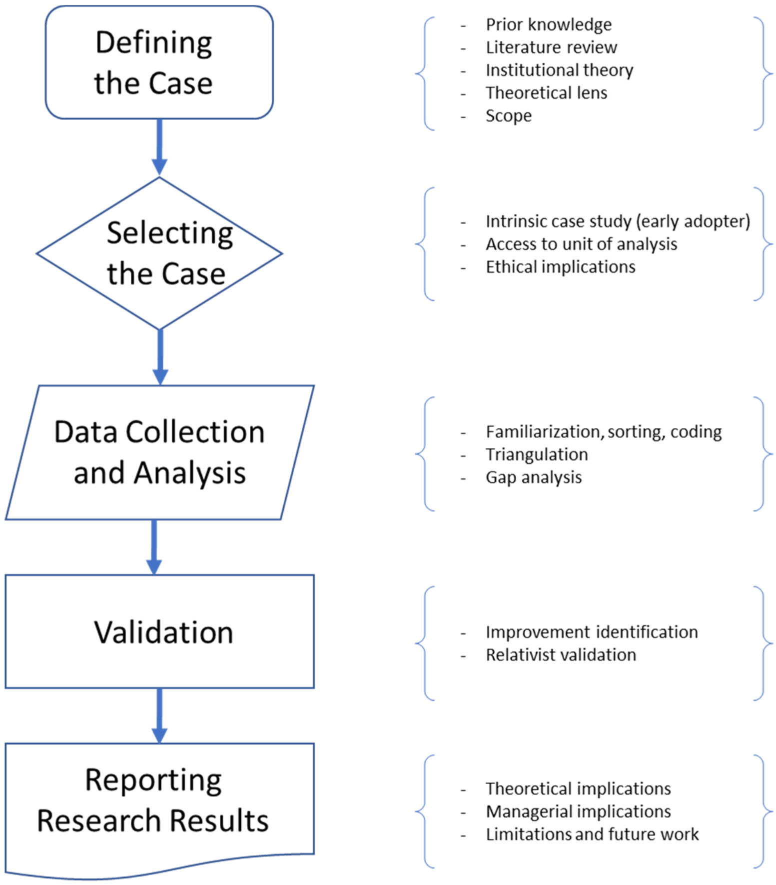

Figure 1. The process flow of this research.

This research relies on relativist validation as opposed to logical empiricist validation. This means that a semiformal and communicative process is employed in which validation is a gradual process of building confidence in the usefulness of new knowledge. Such an approach is appropriate for open problems connected with heuristics and non-precise representations. Literature is used to build confidence in the validity of individual constructs, and confidence in consistency is in the demonstration of adequate input for each step of the research process flow, in the fact that the anticipated output from the step is likely to occur based on the input, and in the fact that the anticipated output is an adequate input to another step. Confidence is built in the appropriateness of the exemplar by relating the exemplar to similar cases. This is followed by accepting the outcome of the chosen exemplar with respect to the initial purpose, linking the achieved usefulness to the method and extending the usefulness beyond the exemplar. The aforementioned validation procedure (the 'Validation Square') has been proposed for engineering design to provide a relativist/holistic/social view [71].

3.1. Case Selection

The selection of a single-case exemplar was appropriate and in accordance with the theoretical sampling approach of the case-study methodology [72]. There are obvious limitations to generalizability with single case studies [67]; however, studying a leading company often leads to useful insights for the purpose of benchmarking and yields deeper observations necessary for underexplored phenomena [73,74]. To support triangulation, multiple investigators were involved to better process the rich contextual data and increase confidence in the research findings [74,75].

The Folgers Coffee Company is part of The J.M. Smucker Company, whose products lead the 10 billion USD at-home retail coffee category. Folgers 1850 coffee was selected as a single-case exemplar for the following reasons:

1. In the 52 weeks that ended 17 May 2020, Folgers was the leading ground coffee brand in the U.S. with over 25% of the market, an increase of about 3% since 2008 [76].
2. The Folgers Coffee Company aims to improve the lives of the farmers who grow their coffee and to purchase green coffee in a responsible manner. Folgers works with UTZ (part of the Rainforest Alliance) to make green-coffee purchases and introduce sustainable coffee practices (UTZ certified as The J.M. Smucker Company, Member ID ME01_7585), and with World Coffee Research (WCR) to protect natural resources ($250,000 to $500,000 category for annual support as J.M. Smucker Co./Folgers Coffee).
3. Folgers 1850 coffee is 100% Colombian. Folgers has partnered with Farmer Connect, a tech start-up building farm-to-fork consumer traceability solutions, to connect consumers of Folgers 1850 coffee with farmers in Colombia.

3.2. Research Setting

The Folgers Coffee Company currently exists in an environment in which other businesses are starting to introduce blockchain given greater concern about compensation for farmers. Examples include Trabocca, a green coffee importer employing Trace by Fairfood to show consumers how coffee from Ethiopia reaches Amsterdam, and Starbucks, which uses blockchain technology so that customers can trace the journey of their coffee beans using a QR code or number on the back of bags of coffee bought in US stores.

3.3. Unit of Analysis

The unit of analysis was a bag of Folgers 1850 coffee. Coffee cherries may be processed using one of three different methods, known as dry, wet, or semi-dry processing [36]. This research focuses on dry processing, as this is the production method of the selected product.

The main by-product of the dry method is the dried skin, pulp and parchment, representing about 12% of the berry on a dry-weight basis [36]. Rotta et al. [77] found that on average, 100 kg of harvested coffee cherries yields 2.6 kg of mass consumed by humans as exported coffee. These by-products, mainly located in the production countries, are often treated as waste that adds to the cost of production [78,79]; however, there exist alternative economic uses such as energy production, chemical compound extraction, and the production of industrial products [80].

Coffee silverskin, also known as chaff, may be the first coffee industry residue produced in consuming countries as it is released during roasting if polishing did not occur before shipping. Spent coffee grounds are the waste produced by brewing coffee. Consequently, the potential feedstock for CE spans agricultural production, industry and consumers starting from origin in Colombia.

3.4. Data Collection

Data collection consisted of four main steps:

1. The lead researcher ordered a bag of Folgers 1850 coffee from amazon.co.uk.
2. The blockchain was investigated using the QR code on the coffee bag.
3. The company (Folgers) was investigated using information available online (sustainability reports, website).
4. Colombian coffee production was investigated using online resources.

The reason for using these steps was to provide a holistic perspective on the production of Folgers 1850 coffee in the context of Colombian coffee production for subsequent thematic analysis [81,82]. The researchers were unsuccessful in attempts to interview supply chain actors including the J.M. Smucker Company, Orrville, OH, USA; Albertsons (retailer, USA); Food Lion (retailer, USA); Harris Teeter (retailer, USA); and Meijer (retailer, USA).

3.5. Data Analysis

As suggested by Kristoffersen et al. [83], the following steps were followed to analyse Folgers 1850 coffee:

1. Determine framework elements and strategies present–are they ecologically embedded?
2. Perform business analytics gap analysis.
3. Identify improvements to circular-oriented innovation that can be enabled with blockchain.

The gap analysis consisted of the following steps [84]:

1. Define the future state as informed by the literature review: The desired future state is ecological embeddedness with farm-to-fork traceability enabling product quality and safety (consumer health benefits), waste identification and location for the inclusion of by-products and waste in CE activities to reduce or recover value and decrease costs (to be shared throughout the supply chain as benefits), and a digital ledger for efficient economic transactions and adequate compensation upstream of the customer and a fair price for the customer (benefits throughout the supply chain).
2. Identify needs: The current state is identified for Folgers 1850 coffee using the physical product and grey literature through the lens of consumer experience. Needs are identified for supply chain actors.
3. Describe the Gap: The gap between the current and future states and contributing factors are described.
4. Bridging the Gap: Solutions are suggested to advance from the current to future state within the context of blockchain.

4. Results

4.1. Data Collection

(1) The Product

A 12 oz (340 g) bag of Folgers 1850 coffee was delivered to the United Kingdom as shown in Figure 2. The bag was printed with the "Juan Valdez and donkey" registered trademark of the Colombian Coffee Growers Federation (FNC). The coffee bag had three stick-on labels attached: a barcode with the description "New–1850 by Folgers Coffee 100% Colombian Light Roast Ground Coffee, 340 g"; a date "20 July 2021" and a QR code with "Learn More 88309001", which was easily removed intact for better scanning of the QR code. The barcode sticker was covering a barcode originally printed on the package, and the date sticker covered a "best if used by" notification printed on the package with the same date as on the sticker and a 13-digit number. The QR code sticker had nothing printed underneath. No UTZ label was found on the package.

(2) The Blockchain

The scanned QR code led to a website (www.thankmyfarmer.com, accessed on 23 January 2022). The products on the website are "traceable" without having to purchase the product. The pop-up titled "Blockchain & farmer connect" read "Farmer Connect uses blockchain to empower the different actors in the ecosystem to share their data in a secure and verifiable manner. The data visualized on this map comes directly from the Farmer Connect platform, uploaded by the different actors." The zoomable map titled "Your product's journey" identified the supply chain starting with two collection centers (Sevilla, Colombia and Manizales, Colombia) as leading to a dry mill (La Variante Sitio La y Salida a Pereira, Pereira, Colombia) and then going to the exporting port in Cartagena. The importing port was identified as New Orleans, LA, USA. From the importing port, two warehouses were identified (Smucker Coffee Silo Operations, 5242 Coffee Drive, New Orleans, Louisiana (LA), USA and Smucker Coffee Almonaster Warehouse, 5050 Almonaster Avenue, New Orleans, Louisiana (LA), USA). From the warehouses, the next identified destination was the roasting facility (The Folgers Coffee Company, 5500 Chef Menteur Highway, New Orleans, Louisiana (LA), USA), and the last location identified was another warehouse (Smuckers Lacombe Distribution Center, 64490 Louisiana-434, Lacombe, LA, USA). Figure 3 is a visualization of the Folgers coffee supply chain.

Figure 2. The product delivered to the United Kingdom.

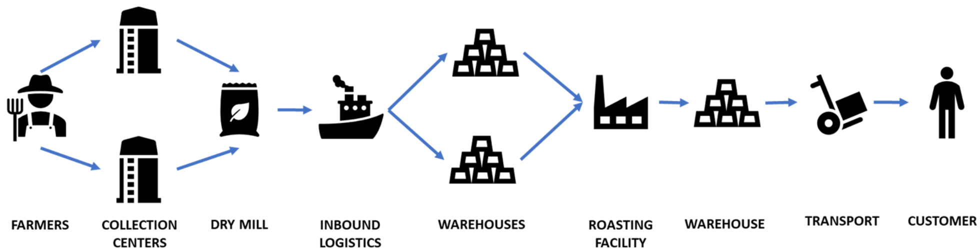

Figure 3. Visualization of the Folgers coffee supply chain.

The following processes of the supply chain can be improved using blockchain technology:

(1) The process of collecting, analysing and making forecasts from supply chain data.
(2) The process of ensuring the security and accuracy of data across the supply chain.
(3) The process of sharing data for improved collaboration across the supply chain.
(4) The process of facilitating and recording financial transactions for greater accuracy and efficiency.
(5) The process of tracing products.
(6) The processes of ensuring product safety and quality.
(7) The process of delivering products more quickly and efficiently.
(8) The process of enabling global supply chain compatibility.
(9) The process of managing and valorising waste (supported by IoT technology).
(10) The marketing process in relation to customer engagement with sustainability.

(3) The Company

Folgers 1850 coffee is a premium brand launched in 2018. The J.M. Smucker Company sources coffee from nearly two dozen countries at any given time. Employees of the J.M. Smucker Company are claimed to be located within major coffee producing regions for the purpose of supporting quality through relationships and transparency. The J.M. Smucker Company has two coffee manufacturing facilities: New Orleans and Suffolk (both USA).

Folgers uses the Farmer Connect website to offer the following:

- The Thank My Farmer^{TM} app for consumers to use to scan a QR code on packaging of a finished good to access the story behind it and donate to sustainability projects in the farmers' communities.
- A farmer connect platform for enterprise clients.

- Farmer ID with a Self-Sovereign Identity (SSI) to allow producers to store and manage digital versions of identification documents, transaction receipts or (agricultural) certifications in one place.

Farmer Connect has been asked by consumers if, using their transparency function, brand owners would share the price paid to farmers in origin countries. Showing farm-gate prices on traced coffee is possible, but Farmer Connect indicates that the industry chooses how to use their tool.

(4) Colombian Coffee Production

The FNC is one of the world's largest nongovernmental agricultural organizations. The mission of the FNC is to ensure the well-being of more than 500,000 coffee growers, with about 95% being small farmers with less than 3 hectares. The organization holds a number of certifications.

The collective savings of the coffee growers gives them access to public funds. One of the most important benefits of the public funds is the guaranteed purchase of the coffee harvest based on market prices and transparency indicators.

The FNC promotes the use of the Smart Coffee ID Card and Smart Coffee Card among the certified coffee growers for financial transactions for the following purposes:

- To receive payment for the sale of their coffee at the Coffee Growers Cooperative.
- To have access to bank operations and purchases at more than 260,000 points: agricultural provision warehouses, cooperative purchase points, ATMs of any network, bank correspondents, Aval Group offices, and commercial establishments, in addition to transactions online and under the ACH (automated clearing house) system.
- To withdraw and send money and for deposits and savings in their bank account.

Colombia also has a Coffee Information System (SICA) containing the descriptions of 1,800,000 lots and socioeconomic data about producers featuring information that is updated by the FNC extension service with over 1500 technicians.

4.2. Data Analysis

(1) Framework Elements and Strategies

From the data collected, no circular strategies were evident related to Folgers 1850 coffee as outlined in the Circular Strategies Scanner [83]. The only apparent strategy was the overarching strategy of supporting farmers to make a financially viable living in which the contribution of the blockchain effort is to externalize this support to consumers.

(2) Gap Analysis

In the context of the ecological embeddedness of the product, production, packaging and the supply chain actors for Folgers 1850 coffee, the blockchain may yield a benefit to farmers arising from the final product packaging if the customer decides to donate money through the Thank My Farmer^{TM} app. However, this is not a direct financial benefit to any specific farmer but rather a potential benefit through the support of projects such as Coffee Seedlings for Smallholder Farmers or Clean Drinking Water and Infrastructure for Schools.

Table 1 summarizes the current needs, desired future state, contributing factors to the gap between the desired future state and current needs and solutions for advancement within the context of blockchain.

(3) Identification of improvements to circular-oriented innovation that can be enabled with blockchain

Opportunities for innovation may be found in examples of best practices or by rethinking and reconfiguring strategic initiatives and the business model including operational processes [83].

Best practices in the case of blockchain may be found outside of the coffee industry: For instance, the pharmaceutical industry is being driven by legislation (the Falsified Medicines Directive in the European Union and the Drug Supply Chain Security Act in the USA) that stipulates that there must be tracking of pharmaceutical products. This (theoretical) best practice demonstrates that end-to-end supply chain actor involvement is viable and could be used to improve the blockchain application in the coffee sector. However, legislation may need to act as a driver.

Table 1. Gap analysis of Folgers 1850 coffee.

	Supply Chain Actor	Current Needs	Desired Future State (Ecological Embeddedness)	Contributing Factors	Bridging the Gap
Columbia/New Orleans, USA	Farmer	Living income	Fair and efficient financial transactions Waste minimization and valorisation	Lack of power	Inclusion in blockchain financial transactions Blockchain for waste
	Collection Dry Mill Exporting Port Importing Port	Supply of coffee	Waste minimization and valorisation	Lack of advanced waste management	Blockchain for waste
J.M. Smucker Company	Warehouse Roasting Facility Warehouse	Supply of coffee Good public relations	Quality and safety of product Waste minimization and valorisation	Lack of incentive	Regulation and legislation for blockchain Full product blockchain traceability and visibility Blockchain for waste
Amazon	Delivery	Good public relations	Quality and safety of product	Lack of integrated technology (e.g., IoT)	Introduction of IoT information into blockchain and integration with upstream supply chain
United Kingdom	Customer	Safe supply of coffee Conscientious consumption (enabled by a connection with the farmer & redirection of coffee grounds from landfill)	Fair price Quality and safety of product	Lack of farm-to-fork transparency Lack of awareness around spent coffee grounds use Lack of access to spent coffee grounds recycling	Increased blockchain transparency Education and participation in blockchain for waste

Waste and blockchain are being considered in the context of CE mainly with regard to plastic waste and electronic waste (e.g., [85,86]). A proposed model for electronic waste considers both forward and reverse supply chains [86]. Blockchain has the added advantage that waste may be tracked across borders [87]. With regard to the collection of waste, a blockchain-based approach using smart contracts has been proposed [88].

Nevertheless, there are wider opportunities to optimise the circularity of the management of non-packaging waste and by-products from the coffee supply chain. The main materials to consider in this regard are coffee husks, pulp, immature or defective beans, coffee silverskin, spent coffee grounds [89] and parts of the plant, such as the flowers, leaves, stems and twigs [90]. Although most of them are currently unused, thermally recycled or used as animal feed, they can be used within the food sector for human consumption [90], which is the ideal solution from a CE point of view, since materials from the food sector remain in it. Furthermore, some of these materials can be used in a wider range of applications, such as to produce biofuel, remove heavy metals and dyes from aqueous solution and extract value-added compounds such as antioxidants and dietary fibres, which can be used in new foods [36].

If such coffee waste and by-products were valorised instead of simply being disposed of, new supply chains would be generated to account for the management of these feedstocks up to the point they are used. This would significantly complicate the overall coffee supply chain, adding new stakeholders and activities. Alves et al. [89] recommended more integrated strategies with the involvement of coffee producers, industries, academic institutions and governmental and nongovernmental organizations to further valorise coffee by-products. Blockchain can support this by making more data available to stakeholders while guaranteeing the data's security and strengthening the accountability of the new products. Taylor et al. [91] argued that blockchain could incentivise sustainable waste management and offer clarity in the property rights related to products and wastes, while maintaining anonymity and privacy for institutions and individuals.

There is also evidence that blockchain can help reduce food waste [92,93], for example by informing stakeholders when abnormal conditions occur [94]. In general, blockchain can help by sharing data about growth conditions, expiry dates, product quality, cultivation methods and processing technology [95]. All this helps with managing inventory, forecasting and planning purchases to suppliers, so there is less need to overbuy, and consequently less food waste is generated. Furthermore, food recalls can be optimised, since it is much easier and faster to identify defective batches. Further opportunities can be realised by co-locating food and biorefining industries to share feedstocks and processing equipment. Sheppard et al. [96] modelled coffee bean roasting co-located with lignocellulosic biorefining of spent coffee grounds, concluding that financial and environmental gains can be achieved. Again, blockchain can support data sharing and therefore strengthen synergies between different industries or even sectors.

IoT can support blockchain by sensing and collecting data to send to the blockchain to create tamperproof records of shared transactions [97]. IoT enables the acquisition of data related to the actual environmental conditions (temperature, humidity, appearance, location, etc.) in which the food product is produced, processed and stored. Data are collected using various sensors (humidity and temperature), cameras (images) and global positioning system (location and movement), and these data may be communicated through technologies such as ZigBee, Bluetooth and WiFi. These technologies collect real-time product data affecting shelf life from farm to fork to minimise food waste [11], predict product shelf life [98] and identify the reasons for food waste [99].

Since the aforementioned considerations of blockchain fail to consider the valorisation of the by-products of production and biological-loop waste at end of life in support of ecologically embedded CE as identified by the gap analysis, best practices are not applicable, and a rethinking and reconfiguring of strategic initiatives and the business model including operational processes are required.

5. Discussion

The aim of this research was to identify how blockchain technology could support ecological embeddedness of the coffee supply chain. The results of the data collection and gap analysis show that blockchain could contribute to ecological relationships among the supply chain actors and the environment by facilitating the sharing of information for a safer supply chain (health benefits for consumers), valorising waste throughout the supply chain in support of CE by highlighting its location and quality with the aid of the IoT to create environmental and economic benefits (cost savings) and improving supply chain relations with greater transparency for the economic and environmental issues of the supply chain (customer loyalty benefits, benefits related to efficiency).

This research indicates via the product marketing of a single-case exemplar under institutional theory that coffee companies may be experiencing decoupling in that organizations superficially accommodate institutional pressures and adopt new technological solutions without necessarily implementing the related practices [100]. The original contribution of this work to the body of knowledge is that blockchain technology has the potential to support the ecological embeddedness of coffee supply chains. The application of the proposed methodology for determining ecological embeddedness yields results that are consistent with previous research yet also enables the identification of means of bridging gaps to achieving ecological embeddedness. Ecological embeddedness supports benefits to all supply chain actors and the natural environment as part of a legitimate approach to CE which is intrinsically important to helping business address modern challenges related to the Sustainable Development Goals, specifically in relation to corporate sustainability, Principle 9 of the UN Global Compact, which states "Encourage the development and diffusion of environmentally friendly technologies".

This single-case exemplar of Folgers 1850 coffee reveals that for ecologically embedded CE as part of the supply chain, there needs to be a consideration of the relationships among supply chain actors and the environment (both natural and business). Relationships are supported both by financial considerations (economic sustainability) through the sharing of benefits among all supply chain actors [49] and for sustainable consumption behaviour through the creation of connections between consumers and producers [101]. Blockchain enabled these relationships, but the single-case exemplar demonstrates that blockchain has not been utilized to its fullest potential. The use of cryptocurrency was not identified as a necessary enabler of these relationships. These findings align with social sustainability and the minimization of risk in the supply chain through user-friendly applications, secure digital payment systems, support for suppliers and farmers and adapting to local conditions [32,102].

The relationships among the supply chain actors are not fully realized in the sense of blockchain farm-to-fork traceability for the Folgers 1850 supply chain. Individual farmers are not visible to consumers even though this would be technically feasible. Consumers may thus be less likely to engage with supporting them. Furthermore, any donations are not linked to a blockchain, so there is little accountability as to how much of the money reaches a specific destination. The supply chain that is visible to consumers does not account for the majority of food miles that the product may have travelled (the USA to the United Kingdom for the single-case exemplar), thereby limiting considerations related to sustainability. The delivering organization also lacks integration with the producer through the blockchain, and this integration could be important for the safety of the consumer and quality of the product with repercussions throughout the supply chain.

Furthermore, the Folgers 1850 supply chain inadequately considers the relationships that are possible within the existing business environment that could enable a more effective blockchain. The FNC has already implemented a number of digital solutions related to farmers that could be integrated into the supply chain. The FNC also supports farmers through fair coffee prices and with the implementation of sustainable agricultural practices. A relationship between Folgers and the FNC would appear to be beneficial, but it does not appear to have been realized. Similarly, although Folgers works with UTZ, which has MultiTrace, a platform supporting traceability of coffee among other products, there is no UTZ certification on the 1850 coffee.

The relationship of the supply chain single-case exemplar with the end user in terms of health and safety is lacking in terms of establishing consumer trust for the delivery of an unadulterated product. Literature has noted that supply chain participants, especially the end customers, need to be able to appreciate the advantages of blockchain technology [33]. There is no direct connection between the blockchain and product quality from the consumer perspective. Coffee has been found to be adulterated using legumes, cereal, nuts and other vegetables, which may be a source of dangerous allergens for some people. However, these forms of adulteration lack caffeine [103]. Although not formally recognized, there is emerging evidence for the impacts of caffeine use disorder (CUD) [104]. When arabica coffee is substituted with cheaper robusta coffee, the caffeine content may increase significantly, which may have implications for CUD. Colombia grows mostly arabica.

Finally, the supply chain analysed in this single-case exemplar was been conceived for environmental sustainability. Waste is present throughout the supply chain in the form of by-products and resources, although there are many potential applications of this waste in support of a CE, many of which could lead to additional revenue. A barrier in the valorisation of this waste is not knowing the quality, quantity and location. Blockchain has the potential to provide the necessary visibility by describing waste as an asset in an associated digital ledger when combined with IoT technology [99].

6. Theoretical Implications

The overarching theoretical contribution of this work is to extend the consideration of ecological embeddedness as defined for individual manufacturers [48] to the supply chain. In this context, the supply chain should be considered in terms of benefits for all of the actors and the environment.

The second contribution of this research is to methodologically extend the theoretical framework [83] to the application of blockchain by detailing the gap analysis. Investigations of ecological embeddedness for other digital technologies may employ the gap analysis steps demonstrated in this research by identifying current needs, the desired future state, contributing factors to the gap between the desired future state and solutions for advancement.

The third theoretical contribution of this work is extending the consideration of blockchain to by-products and waste throughout the supply chain that may be valorised in support of an ecologically embedded CE. Previous research on blockchains has focussed on waste in terms of products at the end of life. This research needs to be extended for greater transparency and therefore access to valuable by-products and waste along the entire supply chain.

7. Managerial Implications

The main managerial implication of this study's findings is that a consumer experience perspective (the theoretical lens used in this research) should not lead to questions about the legitimacy of the implementation of digital technology. Consumer trust is a notable feature meant to be enabled by blockchain [105]. Contradictions that are evident from the investigation of online content regarding the actors in a supply chain may lead to reduced trust and erode perceptions of the brand. An easily removeable QR label which links to an essentially static website showing a supply chain with duplicated nodes not specific to the actual product purchased may not be conducive to increasing consumer trust. Trust is also unlikely to be built on a lack of transparency, whereas disclosure (e.g., prices paid to farmers) would enable equity throughout the supply chain.

A related implication is that for ecological embeddedness, the implementation of digital technology needs to demonstrate mutual benefits through the adaptation of outputs, goals and methods of operation. Establishing a relationship through communicating identification with institutions which have a strong base of legitimacy is a public relations exercise which is not ecologically embedded [12].

8. Limitations and Future Research

The main limitation of this research is the reliance on a single-case exemplar: not all of the findings are generalizable. In particular, not all supply chains will have valorisable waste in sufficient quantity and quality to justify efforts to implement supporting blockchain solutions. Similarly, the supply chain that was studied is not decentralized (third-party platform by Farmer Connect) and avoids most of the typical issues of data immutability and privacy (trust) along with consensus mechanisms. Such implementation may act as a barrier to ecological embeddedness and the extent to which this could be the case would be important future work.

Future research could also focus on the technical aspects of blockchain implementation for ecological embeddedness arising from the Folgers exemplar:

(1) How to resolve traceability issues when the supply chain branches and then reunites commodities (two collection centres leading to one dry mill, two warehouses leading to one roasting facility) both among supply chain actors and within the processes of individual supply chain actors.

(2) How to implement new business models supported by blockchain technology for the valorisation of by-products of production and biological-loop waste at the end of life.

Author Contributions: Conceptualization, H.T. and F.T.; methodology, H.T.; validation, H.T., G.G.-G., S.J. and F.T.; formal analysis, H.T.; investigation, H.T., G.G.-G., S.J. and F.T.; resources, S.J.; data curation, H.T.; writing—original draft preparation, H.T.; writing—review and editing, H.T., G.G.-G., S.J. and F.T.; visualization, H.T.; supervision, G.G.-G.; project administration, F.T.; funding acquisition, S.J. All authors have read and agreed to the published version of the manuscript.

Funding: Guillermo Garcia-Garcia acknowledges the Grant 'Juan de la Cierva Incorporación' funded by MCIN/AEI/ 10.13039/501100011033 by "ESF Investing in your future".

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

References

1. Renard, M. In the Name of Conservation: CAFE Practices and Fair Trade in Mexico. *J. Bus. Ethics* **2010**, *92*, 287–299. [CrossRef]
2. Verteramo Chiu, L.; Liaukonyte, J.; Gómez, M.; Kaiser, H. Socially responsible products: What motivates consumers to pay a premium? *Appl. Econ.* **2017**, *49*, 1833–1846. [CrossRef]
3. Global Coffee Report. A New Baseline for Sustainable Coffee Production. 2021. Available online: https://www.gcrmag.com/a-new-baseline-for-sustainability-in-coffee-production/ (accessed on 13 March 2022).
4. Campos Trigoso, J.-A.; Murga Valderrama, N.L.; Rituay Trujillo, P.A.; García Rosero, L.M. Sostenibilidad del café: Revisión sistemática de la literature. *Rev. Venez. Gerenc.* **2021**, *26*, 943–961. [CrossRef]
5. Yadav, S.; Singh, S. Blockchain critical success factors for sustainable supply chain. *Resources. Conserv. Recycl.* **2020**, *152*, 104505. [CrossRef]
6. Mukherjee, A.; Singh, R.; Mishra, R.; Bag, S. Application of blockchain technology for sustainability development in agricultural supply chain: Justification framework. *Oper. Manag. Res.* **2021**, *in press*. [CrossRef]
7. Adams, R.; Kewell, B.P. Blockchain for Good? Digital Ledger Technology and Sustainable Development Goals. In *Handbook of Sustainability and Social Science Research*; Leal Filho, W., Marans, R., Callewaert, J., Eds.; Springer: Cham, Switzerland, 2018; pp. 127–140. [CrossRef]
8. Sharma, M.G. Supply chain, geographical indicator and blockchain: Provenance model for commodity. *Int. J. Product. Perform. Manag.* **2021**, *in press*. [CrossRef]
9. Thiruchelvam, V.; Mughisha, A.S.; Shahpasand, M.; Bamiah, M. Blockchain-based technology in the coffee supply chain trade: Case of burundi coffee. Journal of Telecommunication. *Electron. Comput. Eng. (JTEC)* **2018**, *10*, 121–125.
10. Jagtap, S.; Bader, F.; Garcia-Garcia, G.; Trollman, H.; Fadiji, T.; Salonitis, K. Food Logistics 4.0: Opportunities and Challenges. *Logistics* **2021**, *5*, 2. [CrossRef]
11. Jagtap, S.; Duong, L.; Trollman, H.; Bader, F.; Garcia-Garcia, G.; Skouteris, G.; Li, J.; Pathare, P.; Martindale, W.; Swainson, M.; et al. IoT technologies in the food supply chain. In *Food Technology Disruptions*; Galanakis, C., Ed.; Academic Press: Cambridge, MA, USA, 2021; pp. 175–211. [CrossRef]
12. Trollman, H.; Colwill, J.; Brejnholt, A. Ecologically Embedded Design in Manufacturing: Legitimation within Circular Economy. *Sustainability* **2020**, *12*, 4261. [CrossRef]
13. Mena, C.; Humphries, A.; Choi, T. Toward a theory of multi-tier supply chain management. *J. Supply Chain. Manag.* **2013**, *49*, 58–77. [CrossRef]
14. Tachizawa, E.; Yew Wong, C. Towards a theory of multi-tier sustainable supply chains: A systematic literature review. *Supply Chain. Manag.* **2014**, *19*, 643–663. [CrossRef]
15. Touboulic, A.; Chicksand, D.; Walker, H. Managing Imbalanced Supply Chain Relationships for Sustainability: A Power Perspective. *Decis. Sci.* **2014**, *45*, 577–619. [CrossRef]
16. Sauer, P.; Seuring, S. A three-dimensional framework for multi-tier sustainable supply chain management. *Supply Chain. Manag.* **2018**, *23*, 560–572. [CrossRef]
17. León-Bravo, V.; Caniato, F.; Caridi, M. Sustainability in multiple stages of the food supply chain in Italy: Practices. *Perform. Reput. Oper. Manag. Res.* **2019**, *12*, 40–61. [CrossRef]
18. Luo, S.; Choi, T.-M. Great partners: How deep learning and blockchain help improve business operations together. *Ann. Oper. Res.* **2021**, *in press*. [CrossRef]
19. Walaszczyk, A.; Galinska, B. Food Origin Traceability from a Consumer's Perspective. *Sustainability* **2020**, *12*, 1872. [CrossRef]
20. Fan, Z.-P.; Wu, X.-Y.; Cao, B.-B. Considering the traceability awareness of consumers: Should the supply chain adopt the blockchain technology? *Ann. Oper. Res.* **2020**, *309*, 837–860. [CrossRef]
21. Sit, J.; Hoang, A.; Inversini, A. Showrooming and retail opportunities: A qualitative investigation via a consumer-experience lens. *J. Retail. Consum. Serv.* **2018**, *40*, 163–174. [CrossRef]
22. Morris, C.; Kirwan, J. Ecological embeddedness: An interrogation and refinement of the concept within the context of alternative food networks in the UK. *J. Rural Stud.* **2011**, *27*, 322–330. [CrossRef]

23. Penker, M. Mapping and measuring the ecological embeddedness of food supply chains. *Geoforum* **2006**, *37*, 368–379. [CrossRef]
24. Feagan, R.B.; Morris, D. Consumer quest for embeddedness: A case study of the Brantford Farmers' Market. *Int. J. Consum. Stud.* **2009**, *33*, 235–243. [CrossRef]
25. Morris, C.; Kirwan, J. Food commodities, geographical knowledge and the reconnection of production and consumption: The case of naturally embedded food products. *Geoforum* **2010**, *41*, 131–143. [CrossRef]
26. Baritaux, V.; Houdart, M.; Boutonnet, J.-P.; Chazoule, C.; Corinaux, C.; Fleury, P.; Lacombe, N.; Napoléone, M.; Tourrand, J.-F. Ecological embeddedness in animal food systems (re-)localisation: A comparative analysis of initiatives in France. *Morocco and Senegal. J. Rural. Stud.* **2016**, *43*, 13–26. [CrossRef]
27. Hedberg, R.C.; Zimmerer, K.S. What's the market got to do with it? Social-ecological embeddedness and environmental practices in a local food system initiative. *Geoforum* **2020**, *110*, 35–45. [CrossRef]
28. Iga, M. Changing agri-food systems in the global economy. *Jpn. J. Hum. Geogr.* **2014**, *66*, 64–76. [CrossRef]
29. Madelrieux, S.; Buchlet, N.; Lescoat, P.; Moraine, M. Characterizing the forms of interaction between agricultural value chains and territories: What methods? *Cah. Agric.* **2017**, *26*, 26. [CrossRef]
30. Zhou, M.; Govindan, K.; Xie, X. How fairness perceptions, embeddedness, and knowledge sharing drive green innovation in sustainable supply chains: An equity theory and network perspective to achieve sustainable development goals. *J. Clean. Prod.* **2020**, *260*, 120950. [CrossRef]
31. Wills, B.; Arundel, A. Internet-enabled access to alternative food networks: A comparison of online and offline food shoppers and their differing interpretations of quality. *Agric. Hum. Values* **2017**, *34*, 701–712. [CrossRef]
32. Chaudhuri, A.; Bhatia, M.S.; Kayikci, Y.; Fernandes, K.J.; Fosso-Wamba, S. Improving social sustainability and reducing supply chain risks through blockchain implementation: Role of outcome and behavioural mechanisms. *Ann. Oper. Res.* **2021**, *in press*. [CrossRef]
33. Berneis, M.; Winkler, H. Value Proposition Assessment of Blockchain Technology for Luxury. *Food Healthc. Supply Chain. Logist.* **2021**, *5*, 85. [CrossRef]
34. Bocken, N.; De Pauw, I.; Bakker, C.; van der Grinten, B. Product design and business model strategies for a circular economy. *J. Ind. Prod. Eng.* **2016**, *33*, 308–320. [CrossRef]
35. Šerešová, M.; Kočí, V. Proposal of Package-to-Product Indicator for Carbon Footprint Assessment with Focus on the Czech Republic. *Sustainability* **2020**, *12*, 3034. [CrossRef]
36. Blinová, L.; Sirotiak, M.; Bartošová, A.; Soldán, M. Review: Utilization of waste from coffee production. *Res. Pap. Fac. Mater. Sci. Technol. Trnava* **2017**, *25*, 91–101. [CrossRef]
37. Arya, S.S.; Venkatram, R.; More, P.R.; Vijayan, P. The wastes of coffee bean processing for utilization in food: A review. *J. Food Sci. Technol.* **2022**, *59*, 429–444. [CrossRef] [PubMed]
38. Thi Quyen, V.; Pham, T.H.; Kim, J.; Thanh, D.M.; Thang, P.Q.; Van Le, Q.; Jung, J.S.H.; Kim, T. Biosorbent derived from coffee husk for efficient removal of toxic heavy metals from wastewater. *Chemosphere* **2021**, *284*, 131312. [CrossRef] [PubMed]
39. Rivest, R.; Shamir, A.; Adleman, L. A method for obtaining digital signatures and public-key cryptosystems. *Commun. ACM* **1978**, *21*, 120–126. [CrossRef]
40. Preneel, B. Cryptographic hash functions. *Eur. Trans. Telecommun.* **1994**, *5*, 431–448. [CrossRef]
41. Vukolić, M. The quest for scalable blockchain fabric: Proof-of-work vs. BFT replication. In *International Workshop on Open Problems in Network Security*; Springer: Berlin/Heidelberg, Germany, 2015. [CrossRef]
42. Kahn, S.A.R.; Godil, D.I.; Jabbour, C.J.C.; Shujaat, S.; Razzaq, A.; Yu, Z. Green data analytics, blockchain technology for sustainable development, and sustainable supply chain practices: Evidence from small and medium enterprises. *Ann. Oper. Res.* **2022**, *in press*. [CrossRef]
43. Janssen, M.; Weerakkody, V.; Ismagilova, E.; Sivarajah, U.; Irani, Z. A framework for analysing blockchain technology adoption: Integrating institutional market and technical factors. *Int. J. Inf. Manag.* **2020**, *50*, 302–309. [CrossRef]
44. Akter, S.; Michael, K.; Uddin, M.R.; McCarthy, G.; Raman, M. Transforming business using digital innovations: The application of AI, blockchain, cloud and data analytics. *Ann. Oper. Res.* **2022**, *308*, 7–39. [CrossRef]
45. Gligor, D.M.; Davis-Sramek, B.; Tan, A.; Vitale, A.; Russo, I.; Golgeci, I.; Wan, X. Utilizing blockchain technology for supply chain transparency: A resource orchestration perspective. *J. Bus. Logist.* **2022**, *43*, 140–159. [CrossRef]
46. Yadav, J.; Misra, M.; Goundar, S. An overview of food supply chain virtualisation and granular traceability using blockchain technology. *Int. J. Blockchains Cryptocurrencies* **2020**, *1*, 154–178. [CrossRef]
47. Yiannas, F. A new era of food transparency powered by blockchain. *Innov. Technol. Governance Glob.* **2018**, *12*, 46–56. [CrossRef]
48. Trollman, H.; Colwill, J. A Transformational Change Framework for Developing Ecologically Embedded Manufacturing. *Glob. J. Flex. Syst. Manag.* **2020**, *21*, 341–368. [CrossRef]
49. Swierczek, A. Manufacturer structural embeddedness and the network rent: The intervening role of relational embeddedness in the triadic supply chains. *Supply Chain. Manag.* **2019**, *24*, 334–354. [CrossRef]
50. Kamble, S.; Gunasekaran, A.; Subramanian, N.; Ghadge, A.; Belhadi, A.; Venkatesh, M. Blockchain technology's impact on supply chain integration and sustainable supply chain performance: Evidence form the automotive industry. *Ann. Oper. Res.* **2021**, *in press*. [CrossRef]
51. Ge, L.; Brewster, C.; Spek, J.; Smeenk, A.; Top, J.; van Diepen, F.; Klasse, B.; Graumans, C.; de Ruyter de Wildt, M. Blockchain for Agriculture and Food; Findings from the pilot study. *Wagening. Econ. Research. Wagening.* **2017**, *112*, 1–33. [CrossRef]

52. Reyna, A.; Martín, C.; Chen, J.; Soler, E.; Díaz, M. On blockchain and its integration with IoT. Challenges and opportunities. *Future Gener. Comput. Syst.* **2018**, *88*, 173–190. [CrossRef]
53. Nowiński, W.; Kozma, M. How can blockchain technology disrupt the existing business models? *Entrep. Bus. Econ. Rev.* **2017**, *5*, 173–188. [CrossRef]
54. Lai, J.-Y.; Wang, J.; Chiu, Y.-H. Evaluating blockchain technology for reducing supply chain risks. *Inf. Syst. E-Bus. Manag.* **2021**, *19*, 1089–1111. [CrossRef]
55. Lacity, M.C. Addressing key challenges to making enterprise blockchain applications a reality. *MIS Q. Exec.* **2018**, *17*, 201–222.
56. Weking, J.; Mandalenakis, M.; Hein, A.; Hermes, S.; Böhm, M.; Krcmar, H. The impact of blockchain technology on business models—A taxonomy and archetypal patterns. *Electron. Mark.* **2020**, *30*, 285–305. [CrossRef]
57. Baert, K.; Van Huffel, X.; Jacxsens, L.; Berkvens, D.; Diricks, H.; Huyghebaert, A.; Uyttendaele, M. Measuring the perceived pressure and stakeholders' response that may impact the status of the safety of the food chain in Belgium. *Food Res. Int.* **2012**, *48*, 257–264. [CrossRef]
58. Kumar, S.; Luthra, S.; Haleem, A. Customer involvement in greening the supply chain: An interpretive structural modeling methodology. *J. Ind. Eng. Int.* **2013**, *9*, 1–13. [CrossRef]
59. Martínez-Jurado, P.J.; Moyano-Fuentes, J. Lean management, supply chain management and sustainability: A literature review. *J. Clean. Prod.* **2014**, *85*, 134–150. [CrossRef]
60. Reuter, C.; Goebel, P.; Foerstl, K. The impact of stakeholder orientation on sustainability and cost prevalence in supplier selection decisions. *J. Purch. Supply Manag.* **2012**, *18*, 270–281. [CrossRef]
61. Masudin, I.; Wastono, T.; Zulfikarijah, F. The effect of managerial intention and initiative on green supply chain management adoption in Indonesian manufacturing performance. *Cogent Bus. Manag.* **2018**, *5*, 1485212. [CrossRef]
62. Masudin, I.; Ramadhani, A.; Restuputri, D.P.; Amallynda, I. The Effect of Traceability System and Managerial Initiative on Indonesian Food Cold Chain Performance: A COVID-19 Pandemic Perspective. *Glob. J. Flex. Syst. Manag.* **2021**, *22*, 331–356. [CrossRef]
63. Miles, M.; Huberman, A. *Qualitative Data Analysis*; Sage: London, UK, 1994.
64. Yin, R. *Case Study Research: Design and Methods*; Sage: Thousand Oaks, CA, USA, 2003.
65. Wang, M.; Kumar, V.; Ruan, X.; Saad, M.; Garza-Reyes, J.A.; Kumar, A. Sustainability concerns on consumers' attitude towards short food supply chains: An empirical investigation. *Oper Manag Res.* **2021**, *in press*. [CrossRef]
66. Voss, C.; Tsikriktsis, N.; Frohlich, M. Case research in operations management. *Int. J. Oper. Prod. Manag.* **2002**, *22*, 195–219. [CrossRef]
67. Eisenhardt, K.M.; Graebner, M.E. Theory building from cases: Opportunities and challenges. *Acad. Manag. J.* **2007**, *50*, 25–32. [CrossRef]
68. Crowe, S.; Cresswell, K.; Robertson, A.; Huby, G.; Avery, A.; Sheikh, A. The case study approach. *BMC Med. Res. Methodol.* **2011**, *11*, 100. [CrossRef] [PubMed]
69. Yin, R.K. Case study research. In *Design and Methods*, 5th ed.; Sage: Thousand Oaks, CA, USA, 2014.
70. Stake, R.E. *The Art of Case Study Research*; Sage: Thousand Oaks, CA, USA, 1995.
71. Pedersen, K.; Emblemsvåg, J.; Bailey, R.; Allen, J.K.; Mistree, F. Validating Design Methods & Research: The Validation Square. In Proceedings of the DETC '00, Baltimore, MA, USA, 10–14 September 2000.
72. Alvarez, G.; Pilbeam, C.; Wilding, R. Nestlé Nespresso AAA sustainable quality program: An investigation into the governance dynamics in a multi-stakeholder supply chain network. *Supply Chain Manag.* **2010**, *15*, 165–182. [CrossRef]
73. Barratt, M.; Choi, T.; Li, M. Qualitative case studies in operations management: Trends, research outcomes, and future research implications. *J. Oper. Manag.* **2011**, *29*, 329–342. [CrossRef]
74. Benbasat, I.; Goldstein, D.; Mead, M. The case research strategy in studies of information systems. *MIS Q.* **1987**, *11*, 368–386. [CrossRef]
75. Eisenhardt, K. Building theories from case study research. *Acad. Manag. Rev.* **1989**, *14*, 532–550. [CrossRef]
76. Datta, Y. The U.S. Coffee Market: A Competitive Profile. *J. Econ. Public Financ.* **2020**, *6*, 138–171. [CrossRef]
77. Rotta, N.; Curry, S.; Han, J.; Reconco, R.; Spang, E.; Ristenapart, W.; Donis-González, I. A comprehensive analysis of operations and mass flows in postharvest processing of washed coffee. *Resour. Conserv. Recycl.* **2021**, *170*, 105554. [CrossRef]
78. Chanakya, H.; De Alwis, A. Environmental issues and management in primary coffee processing. *Process Saf. Environ. Prot.* **2004**, *82*, 291–300. [CrossRef]
79. Coltro, L.; Mourad, A.; Oliveira, P.; Baddini, J.; Kletecke, R. Environmental profile of Brazilian green coffee. *Int. J. Life Cycle Assess.* **2006**, *11*, 16–21. [CrossRef]
80. Esquivel, P.; Jiménez, V. Functional properties of coffee and coffee by-products. *Food Res. Int.* **2012**, *46*, 488–495. [CrossRef]
81. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [CrossRef]
82. Nowell, L.; Norris, J.; White, D.; Moules, N. Thematic Analysis: Striving to Meet the Trustworthiness Criteria. *Int. J. Qual. Methods* **2017**, *16*, 1609406917733847. [CrossRef]
83. Kristoffersen, E.; Blomsma, F.; Mikalef, P.; Li, J. The smart circular economy: A digital-enabled circular strategies framework for manufacturing companies. *J. Buiness Res.* **2020**, *120*, 241–261. [CrossRef]
84. Bunse, K.; Vodicka, M.; Schönsleben, P.; Brülhart, M.; Ernst, F. Integrating energy efficiency performance in production management—gap analysis between industrial needs and scientific literature. *J. Clean. Prod.* **2011**, *19*, 667–679. [CrossRef]

85. Chidepatil, A.; Bindra, P.; Kulkarni, D.; Qazi, M.; Kshirsagar, M.; Sankaran, K. From Trash to Cash: How Blockchain and Multi-Sensor-Driven Artificial Intelligence Can Transform Circular Economy of Plastic Waste? *Adm. Sci.* **2020**, *10*, 23. [CrossRef]
86. Sahoo, S.; Mukherjee, A.; Halder, R. A unified blockchain-based platform for global e-waste management. *Int. J. Web Inf. Syst.* **2021**, *17*, 449–479. [CrossRef]
87. Schmelz, D.; Pinter, K.; Strobl, S.; Zhu, L.; Niemeier, P.; Grechenig, T. Technical Mechanics of a Trans-Border Waste Flow Tracking Solution Based on Blockchain Technology. In Proceedings of the 2019 IEEE 35th International Conference on Data Engineering Workshops (ICDEW), Macao, China, 8–12 April 2019; pp. 31–36. [CrossRef]
88. Gupta, Y.; Mukherjee, S.; Dutta, R.; Bhattacharya, S. A blockchain-based approach using smart contracts to develop a smart waste management system. *Int. J. Environ. Sci. Technol.* **2021**, *in press*. [CrossRef]
89. Alves, R.C.; Rodrigues, F.; Nunes, M.A.; Vinha, A.F.; Oliveira, M.B.P.P. Chapter 1—State of the art in coffee processing by-products. In *Handbook of Coffee Processing By-Products*; Galanakis, C.M., Ed.; Elsevier: Amsterdam, The Netherlands, 2017; pp. 1–26. [CrossRef]
90. Klingel, T.; Kremer, J.I.; Gottstein, V.; Rajcic de Rezende, T.; Schwarz, S.; Lachenmeier, D.W. A review of coffee by-products including leaf, flower, cherry, husk, silver skin, and spent grounds as novel foods within the European Union. *Foods* **2020**, *9*, 665. [CrossRef]
91. Taylor, P.; Steenmans, K.; Steenmans, I. Blockchain technology for sustainable waste management. *Front. Political Sci.* **2020**, *2*, 590923. [CrossRef]
92. Li, K.; Lee, J.-Y.; Gharehgozli, A. Blockchain in food supply chains: A literature review and synthesis analysis of platforms, benefits and challenges. *Int. J. Prod. Res.* **2021**, *in press*. [CrossRef]
93. Marin, M.P.; Marin, I.; Vidu, L. Learning about the reduction of food waste using blockchain technology. In Proceedings of the 13th Annual International Technology, Education and Development, Valencia, Spain, 11–13 March 2019. [CrossRef]
94. Zhao, Z.; Min, K.J. Blockchain traceability valuation for perishable agricultural products under demand uncertainty. *Int. J. Oper. Res. Inf. Syst.* **2020**, *11*, 1–32. [CrossRef]
95. Kör, B.; Krawczyk, A.; Wakkee, I. Addressing food loss and waste prevention. *Br. Food J.* **2021**, *in press*. [CrossRef]
96. Sheppard, P.; Garcia-Garcia, G.; Angelis-Dimakis, A.; Campbell, G.M.; Rahimifard, S. Synergies in the co-location of food manufacturing and biorefining. *Food Bioprod. Process.* **2019**, *117*, 340–359. [CrossRef]
97. Lamichhane, M. *A Smart Waste Management System Using IoT and Blockchain Technology*; LUT University: Lappeenranta, Finland, 2017.
98. Jagtap, S. *Utilising the Internet of Things Concepts to Improve the Resource Efficiency of Food Manufacturing*; Loughborough University: Loughborough, UK, 2019. [CrossRef]
99. Jagtap, S.; Bhatt, C.; Thik, J.; Rahimifard, S. Monitoring Potato Waste in Food Manufacturing Using Image Processing and Internet of Things Approach. *Sustainability* **2019**, *11*, 3173. [CrossRef]
100. Boxenbaum, E.; Jonsson, S. Isomorphism, diffusion and decoupling. In *The Sage Handbook of Organizational Institutionalism*; Greenwood, R., Oliver, C., Lawrence, T.B., Meyer, R.E., Eds.; Sage: London, UK, 2008; pp. 78–98.
101. Weber, H.; Loschelder, D.; Lang, D.; Wiek, A. Connecting consumers to producers to foster sustainable consumption in international coffee supply—A marketing intervention study. *J. Mark. Manag.* **2021**, *37*, 1148–1168. [CrossRef]
102. Saberi, S.; Kouhizadeh, M.; Sarkis, J.; Shen, L. Blockchain technology and its relationships to sustainable supply chain management. *Int. J. Prod. Res.* **2019**, *57*, 2117–2135. [CrossRef]
103. Florez-Valdez, M.; Meza-Márquez, O.; Osorio-Revilla, G.; Gallardo-Velázquez, T. Identification and Quantification of Adulterants in Coffee (*Coffea arabica* L.) Using FT-MIR Spectroscopy Coupled with Chemometrics. *Foods* **2020**, *9*, 851. [CrossRef]
104. Booth, N.; Saxton, J.; Rodda, S. Estimates of Caffeine Use Disorder, Caffeine Withdrawal, Harm and Help-seeking in New Zealand: A cross-sectional survey. *Addict. Behav.* **2020**, *109*, 106470. [CrossRef]
105. 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]