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RESEARCH ARTICLE

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Evidence-driven model for implementing Blockchain in food supply chains

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ABSTRACT

Blockchain technology has been identified as a possible solution to address critical challenges faced by the food sector. Building on the potential of Blockchain within Food Supply Chains (FSC), this study aims to develop an evidence-based implementation model for Blockchain in the food industry. Innovation Adoption and other prominent theories are integrated to first develop a conceptual framework, which is later validated following an analysis of the qualitative data. Fifteen semi-structured expert interviews are used to develop an evidence-driven, applied model for implementing Blockchain; providing detailed insights into typical stages, associated activities, and contextual determinants needed for successful integration. An empirically validated implementation model advances the extant academic literature and further provides a detailed roadmap for food practitioners, while initiating Blockchain projects with their firms and/or supply chains.

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Blockchain; implementation framework; innovation adoption; food supply chain

1. Introduction

Food is an important aspect of our society and economy. On average, 17% of a UK household income is spent on food (Office for National Statistics 2020), and the EU recognised the food and drink industry as one of the largest sectors with a turnover of more than 1 trillion Euro in 2019 (Food Drink Europe 2019). However, the modern agriculture and food industry has been facing persistent challenges in managing food safety, quality, and sustainability due to increasingly globalised, complex, and fragmented supply lines (Akkerman, Farahani, and Grunow 2010; Routroy and Behera 2017). Subsequently, the food industry has heavily invested in information systems and modern technology for better management of food products (Routroy and Behera 2017; Kamble, Gunasekaran, and Gawankar 2020). Blockchain technology has recently emerged as a unique technology that can solve critical issues identified in food supply chains (Zhao et al. 2019; Tan, Gligor, and Ngah 2020). A notable example is Carrefour, a European food retailer, which initiated Blockchain for its poultry products in 2018, anticipating full traceability of this product line in 2022 (Carrefour 2020). Similarly, Nestlé and IBM are attempting to monitor the sustainability of their coffee, milk, and palm oil (Nestlé Global 2020). Furthermore, Walmart successfully piloted Blockchain for tracking mangoes and pork and is moving toward fully integrating Blockchain into their operations (Hyperledger 2019).

When examining transformative technologies (such as Blockchain), one of the most critical aspects is to understand the implementation at the organisational level. For instance, the adoption of ERP has long been examined in the literature (see highly cited works such as Liang et al. (2007) or

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Schniederjans and Yadav (2013)) and is well understood among practitioners with numerous integration guidelines provided by reputable service providers (e.g. SAP 2022) and consulting companies (e.g. Deloitte 2022). RFID is another transformative technology that has received considerable attention from researchers (Kim and Garrison 2010; Hossain, Quaddus, and Islam 2016). The food industry has been at the forefront of exploring Blockchain since it is first considered for Supply Chain Management (SCM), and the technology has subsequently gained substantial momentum with numerous ongoing initiatives. Therefore, a specific study that examines the implementation process of Blockchain in FSC, with supporting empirical evidence, has tremendous opportunities to contribute to both literature and practice.

Some early attempts at investigating the adoption of Blockchain in the wider SCM domain are evident in the extant literature. However, most studies examine the decision to adopt Blockchain and the different factors leading to such a decision (Kamble, Gunasekaran, and Arha *2019*; Queiroz et al. 2020; Wong et al. 2020; Falcone, Steelman, and Aloysius 2021). Understanding how an organisation decides to adopt Blockchain is valuable, yet there is a lack of clarity on the Blockchain adoption process within organisations. The life cycle of technology innovation does not stop after the adoption decision (Wamba and Queiroz 2022). A comprehensive understanding of the technology implementation process can lead to successful integration, creating business value (Zhu et al. 2006; Pichlak 2016). A limited number of studies explore this endeavour; however, most of them are conceptual (Hughes et al. 2019) or lack a strong theoretical foundation (van Hoek 2019). Therefore, it can be seen that the current body of literature remains short of holistic approaches to examining the implementation process of Blockchain at the organisational/SC level. Furthermore, scholars continue to advocate for in-depth inquiries about the adoption process of Blockchain in specific types of industries, to address sector-specific challenges, and to justify the value of Blockchain for improving supply chain performance (van Hoek 2019; Wamba and Queiroz 2022). Considering the critical challenges faced by FSC and the potential growth of Blockchain in this particular domain, it can be further inferred that the literature currently lacks empirical studies exploring the Blockchain adoption journey in the FSC.

To minimise this evident gap, this study aims to answer the following research questions (RQ):

RQ1: How do organizations in the FSC implement Blockchain technology?

RQ2: What are the main determinants of the implementation process of Blockchain in the context of FSC?

while attempting to find answers to the above questions, this study develops an evidence-based model for Blockchain implementation in the FSC, providing detailed insights into adoption stages, associated activities, and contextual determinants needed for successful adoption. First, a conceptual framework for Blockchain implementation in the FSC setting is proposed, utilising prominent theories and established frameworks in the Innovation Adoption (IA). The IA perspective is a suitable foundation to study the adoption of Blockchain, as it has been used successfully to examine similar processes of other technologies (Hameed, Counsell, and Swift 2012; Martins, Oliveira, and Thomas 2016) as well as of Blockchain in other management fields (Kamble, Gunasekaran, and Arha 2019; Queiroz et al. 2020). Further, the conceptual framework also inherits the key findings in prior work by the authors (Vu, Ghadge, and Bourlakis 2021) to ensure its relevance when applied to the specific context of FSC. Then, qualitative data (from interviews) is gathered to validate and improve the conceptual framework, resulting in a practical model for implementing Blockchain in the FSC. The contributions of this study thus are two-fold. First, practitioners can draw valuable insights and lessons from early Blockchain adopters in the FSC and further use the implementation model developed in this study as a useful reference for their Blockchain projects. Second, this study also contributes to the Blockchain for SCM literature, as it combines contextual empirical evidence (from in-depth interviews) with a theoretical understanding of implementing technological innovation to develop a specific model of Blockchain implementation for organisations in the FSC.

The rest of this study is structured as follows: Section 2 provides the background for this research; Section 3 discusses the methodology and the data collection process; Section 4 presents the findings from the data; Section 5 highlights the final implementation model and the implications of the study. Finally, conclusions, limitations, and future research endeavours are presented in Section 6.

2. Background to the research

2.1. Blockchain in the FSC

The FSC can be broadly defined as a collection of activities from the first point of production (e.g. production of crops, livestock, etc.) to the final point of consumption and/or disposal (Dossa et al. 2020). Food products possess distinct characteristics such as perishability, seasonality, and dependence on climate, and suffer from persistent issues such as high price volatility, security, and serious wastage (Barbosa 2021); thus, they pose unique challenges regarding production, transporting, storing, monitoring quality and safety, and material recycling (Fredriksson and Liljestrand 2015; Barbosa 2021). Furthermore, product traceability and transparency are significant issues for FSC management (FSCM) due to multiple food-related scandals/recalls in the past, and the fact that food supply chains are increasingly globalised and complex nowadays (Routroy and Behera 2017; Kamble, Gunasekaran, and Gawankar 2020).

To overcome the critical challenges of managing food products, Blockchain has been seen as a potential remedy (Kamilaris, Fonts, and Prenafeta-Boldú 2019; Zhao et al. 2019). At the core, Blockchain can be understood as a distributed ledger technology. The name of the technology stemmed from the unique mechanism, by which information gets stored and distributed. Transactions and/or information are first bundled into a block, then validated by the majority of participants of the Blockchain network, and, finally, the new block of information is linked to the previously created block by a unique hash number, creating a chain of blocks (Belotti et al. 2019; Kumar, Liu, and Shan 2020). Further, Blockchain is append-only, meaning recorded information cannot be changed, and additional blocks must be created to store new data. Blockchain is decentralised, meaning there is no overseeing party of the ledger; rather, every network member holds an authentic copy of the ledger. These characteristics make Blockchain an effective means of storing and sharing tamper-proof information with high security, integrity, and real-time accessibility (Wamba and Queiroz 2022). Consequently, Blockchain can improve FSCM by facilitating reliable information sharing, increasing trust and accountability of records, and extending the visibility of the supply chain (Tan, Gligor, and Ngah 2020). Thus in FSC, Blockchain has been prominently used to enhance the traceability process, improve the management of food inventory, and communicate information about food provenance and integrity to end consumers (Kamilaris, Fonts, and Prenafeta-Boldú 2019).

2.2. Conceptual framework for blockchain implementation

This study proposes to examine the integration of Blockchain in FSCs under the theoretical lenses of IA. Broadly, there are two dominant perspectives in IA research: innovation variance research and dichotomy of innovation process research (Hameed, Counsell, and Swift 2012). Innovation variance research focuses on examining the influence of relevant factors on the adoption decision of, and/or the intention to use an innovation. Some popular theories and perspectives for the first stream include the Technology-Organization-Environment (TOE) framework (Tornatzky, Fleischer, and Chakrabarti 1990), Technology Acceptance Model (TAM) (Davis 1989), and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al. 2003) and its later extension UTAUT2 (Venkatesh, Thong, and Xu 2012). The factor approach has been widely employed to study Blockchain adoption in the domain of SCM. Some representative examples include – Kamble, Gunasekaran, and Arha (2019) examined Blockchain adoption for SCM in

India using a combination of TAM and other theories such as the theory of planned behaviour; Queiroz et al. (2020) studied the same topic, but in a generic SCM setting under the lens of UTAUT, and Wong et al. (2020) employed TOE to develop a model exploring Blockchain adoption among Malaysian SMEs.

In contrast, the process approach does not view the adoption of new technological innovation as a one-off decision of whether or not to use said technology, but rather as a series of sequential stages through which technology is examined, adopted, and finally integrated into an organisation (Hameed, Counsell, and Swift 2012; Pichlak 2016). Since this study aims to develop a framework for the Blockchain implementation process in FSC organisations, it is more aligned with the innovation process stream of research. Compared to the innovation variance perspective, the process approach has been overlooked in the context of adopting Blockchain for SCM and especially FSCM. To the authors' best knowledge at the time of writing this study, there has been only one study by Wamba and Queiroz (2022), examining the Blockchain implementation process in the generic SCM setting.

To achieve the objective of the study, a conceptual framework of Blockchain implementation for organisations in FSC is first introduced and later validated and improved with the insights from the empirical data. To develop the conceptual framework, two key aspects need to be determined: the stages of integrating Blockchain and the potential determinants. To this end, prominent theories and established models of IA are utilised to define those aspects. Thus, it can be seen that this study does not hinge on a single theory or perspective but adopts an integrative approach in formulating the conceptual framework. The premise is that relying on a single theoretical perspective may not be sufficient to provide a comprehensive understanding of complex technology adoption (Hameed, Counsell, and Swift 2012; Wamba and Queiroz 2022). Thus, to better comprehend the phenomenon, integrating different theoretical perspectives into one model – an integrative model approach – is often used to provide more explanatory power to the topic under research (Martins, Oliveira, and Thomas 2016; Kamble, Gunasekaran, and Gawankar 2020; Wamba and Queiroz 2022).

Extant literature proposed a variety of phases for adopting innovation; for instance: initiation, adoption, and routinisation (Zhu et al. 2006); initiation, adoption decision, and implementation (Hameed, Counsell, and Swift 2012; Pichlak 2016); intention to adopt, adoption, and routinisation (Martins, Oliveira, and Thomas 2016; Wamba and Queiroz 2022); initiation, adoption, routinisation, and extension (Hossain, Quaddus, and Islam 2016); and initiation, adoption, and assimilation (Nam, Lee, and Lee 2019). Overall, although the generalisation of concepts and the used terminologies differ, the essential process and associated activities for the adoption of new technology are consistent throughout existing models, and can be grouped into three general phases: (1) **Initiation** – the organisation explores various aspects of the innovation in consideration, (2) **Adoption decision** – the organisation decides whether and how to implement the innovation, and (3) **Implementation** – the organisation deploys large scale implementation and integrates the innovation into its structure.

Besides the phases by which an innovation is integrated into an organisation, broad categories of determinants to the implementation process are identified based on prominent theories and models from extant IA literature. These determinants can influence the propensity to adopt new technology (Zhu et al. 2006), as well as the success and adequacy of each implementation stage (Hameed, Counsell, and Swift 2012; Pichlak 2016). As observed from the literature, the influential factors to the implementation process of technology can be broadly categorised into four dimensions: technology, organisation, environment, and management. Diffusion of Innovation (DoI), proposed by Rogers (2003), suggested that certain characteristics of new technology, namely relative advantage, complexity, compatibility, trialability, and observability, can influence its adoption. Technology is also a core element in the TOE framework developed by Tornatzky, Fleischer, and Chakrabarti (1990). The other two categories in this framework are organisation characteristics (e.g. size, structure, resources, etc.) and environment characteristics (e.g. market, industry, country, etc.). Management is another important cluster of determinants, as managers possess critical roles in

championing and realising the implementation of new technologies and, therefore, should be examined thoroughly (Hameed, Counsell, and Swift 2012; Pichlak 2016). These four main categories of determinants thus feature in a great number of integrative models for the implementation of technologies such as RFID (Hossain, Quaddus, and Islam 2016), IT technology (Hameed, Counsell, and Swift 2012), software as a service (Martins, Oliveira, and Thomas 2016), or business analytics software (Nam, Lee, and Lee 2019).

Drawing from related IA theories and models discussed previously, a conceptual framework (presented in Figure 1) is introduced. Moreover, the framework proposed in this study greatly resonates and is inspired by an earlier conceptual work by Vu, Ghadge, and Bourlakis (2021). In the prior study, insights from studies exploring Blockchain usage and adoption in FSCM were synthesised and combined with IA literature to develop a theoretical framework for integrating the technology at the organisational level in the FSC setting. Thus readers can refer to Vu, Ghadge, and Bourlakis (2021) to see the relevance of the conceptual framework in the context of Blockchain adoption in FSC.

3. Methodology

A qualitative methodology is applied for this study. It is observed that quantitative research is dominantly used in IA literature to study the implementation of various technologies such as RFID (Hossain, Quaddus, and Islam 2016), software as a service (Martins, Oliveira, and Thomas 2016), e-business (Zhu et al. 2006), or Blockchain for SCM in general (Wamba and Queiroz 2022; Wong et al. 2020). Nevertheless, the authors opted for a qualitative approach because the body of research regarding the Blockchain phenomenon, especially in a specific setting such as the FSC, is still regarded as in early development (Cole, Stevenson, and Aitken 2019; Zhao et al. 2019). Thus drawing a definite conclusion about the phases of implementation and pertinent factors to such a process can be difficult. Moreover, for studying novel technology, qualitative research is a preferred method to gain in-depth insights into the phenomenon and to provide valuable foundations for further quantitative studies in the future as the body of literature also progresses over time (Wang et al. 2019; Lohmer and Lasch 2020). Therefore, it is argued that a qualitative approach is suitable for this instance, given the current development of Blockchain for FSCs.

3.1. Data collection

For conducting interviews, public sources such as news articles and industry reports were used to identify companies in the food industry that have initiated the adoption of Blockchain. Next, letters

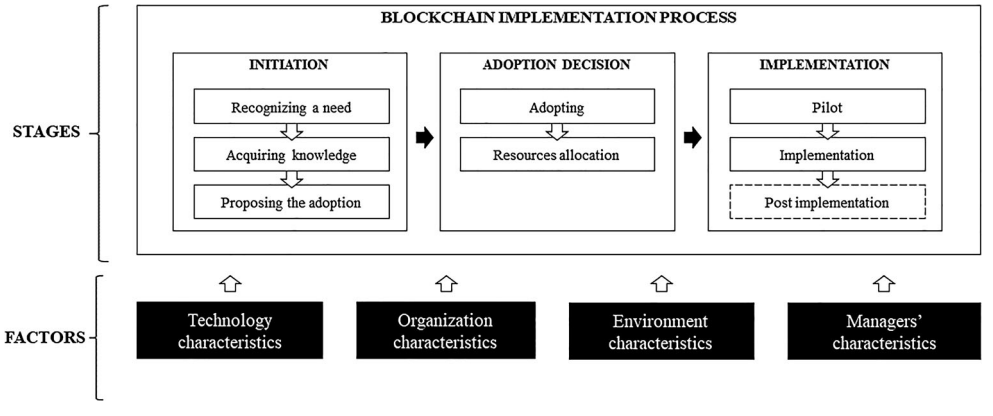

Figure 1. A conceptual framework for implementing Blockchain in FSC (Adapted from Vu, Ghadge, and Bourlakis 2021).

of invitation were sent (via either conventional email or LinkedIn mail) to individuals in selected companies directly involved in the Blockchain projects. Potential candidates for the interviews from 47 companies were contacted and, subsequently, representatives from 15 companies agreed to participate in the research (31% rate of response). 15 semi-structured expert interviews (with an average time of one hour each) were conducted from March 2021 to July 2021. Table 1 provides an overview of those participants (P). To generalise our findings to a broad range of organisations in the FSC, we invited participants from different nodes of the FSC and have diverse expertise. Further, all identified interviewees have worked on Blockchain projects in food industries from various parts of the globe (e.g. Australia, the UK, the US, the EU, India, South America, East Asia, and Africa).

An interview protocol was designed, with questions focusing on the set of activities a company often goes through in the process of integrating Blockchain, and various influential factors to such a process. Further, the authors continued to revise the protocol after each of the first three interviews to improve clarity, language, and the relevance of questions. The changes were minor; thus valuable insights were gained in the first three interviews and included in the analysis. Later, the protocol remained consistent throughout the rest of the interviews (See Appendix A for the interview protocol). Moreover, consent to record interviews was collected both verbally and in writing. One participant did not want to record the session, thus the interviewer took notes of answers and confirmed with them afterwards.

Table 1. Description of interviewees.

	Position	Details about the companies	Experience
P1	Quality manager	Fruit producer with 7 large facilities, leading grower of some products in Australia.	15 + years
P2	Business development manager	Blockchain service provider with experience in implementing Blockchain for a wide range of actors in the food chain (cooperatives, producers, importers, retailers).	5 + years
P3	Sales executive	Seafood producer, one of the largest shrimp suppliers in South America.	10 + years
P4	General manager	Blockchain service provider, with experience in implementing Blockchain for large and medium-size organisations in the food chain.	5 + years
P5	CEO	Blockchain service provider, with experience in implementing Blockchain for a large pig producer in East Asia.	20 + years
P6	Founder & CEO	Blockchain service provider with experience in piloting Blockchain for a medium-size seafood producer in Northern EU.	20 + years in technology adoption, 4 + years in the food industry
P7	Project manager	Food regulator with direct experience of experimenting with Blockchain for meat and wine products in the UK.	5 + years
P8	Project manager	Blockchain service provider, with experience in implementing Blockchain for a small distillery in the EU.	2 + years
P9	Founder & CEO	Seafood reseller, medium-size company in the US.	10 + years
P10	Founder & CEO	Blockchain service provider	5 + years
P11	Senior consultant	Consulting service	10 + years
P12	Director of emerging technology	Blockchain and software service, with experience of pilot Blockchain for tea producers in South America.	10 + years
P13	Founder & CEO	Processed food manufacturer, a medium-size company in India.	4 + years
P14	Founder & CEO	Service provider, with experience in working with small and medium livestock farms in Africa.	15 + years
P15	A team consists of the CEO, Marketing head, and Blockchain project lead	Olive oil producer, large size company in EU.	Member with least experience has had 5 + years in the food industry

3.2. Data analysis

Each interview was conducted virtually using Zoom, and then auto transcribed by the platform. The first author, after each interview, validated the auto transcription with the recorded audio to correct any mistakes, while also outlining initial observations of answers from participants. Data saturation was reached after the fifteenth interview as the interviewer perceived no new information. Compared to other qualitative studies that also examine the use of Blockchain for SCM, such as Lohmer and Lasch (2020) with 10 interviews or Kurpjuweit et al. (2019) with 12 interviews, the number of interviews included in this study is found to be sufficient.

After all the interviews were concluded, 237 pages of transcriptions were generated. Coding is the method of choice for analyzing qualitative data. NVivo 12 software was used to aid the process. Two cycles of coding were performed, namely concept coding and axial coding. Concept coding can be used to effectively capture the broader idea beyond the tangible responses, and axial coding is a suitable follow-up approach as it links separate data from the first coding cycle to categories, links sub-categories with more conceptual ones, and defines the relationship between categories (Saldaña 2021). Literature on innovation adoption was utilised during the coding process, as the authors went back and forth between extant literature and qualitative data to improve on the concepts used for capturing the meaning of datum, establish the relationships between different concepts, and cluster concepts under a more abstract theme and/or dimension. Table 2 illustrates how the specific concept of the organisation's innovativeness; part of the organisation dimension was induced from the qualitative data. For the complete development of the first-order concepts and their illustrative codes, second-order themes, and aggregated dimensions, see Appendix B.

4. Findings

Insights provided by experts were found to be largely aligned with existing literature regarding the implementation of Blockchain. At a broad level, the journey of Blockchain adoption at different organisations in the food supply chain often unfolds over three broad phases of the implementation process: Initiation, Adoption, Implementation; and four groups of determinants – Technology, Organisation, Environment, and Management are found to be relevant to the process. However, at a more granular level, the data revealed interesting findings that helped improve and validate the conceptual framework, particularly with identifying the detailed list of core activities during the Blockchain project, the sequences of these activities, and additional insights associated with the implementation process. Interestingly, since the experts come from various backgrounds (food producers, food processors, food distributors, and food specific Blockchain service providers), they offered diverse perspectives on their adoption journeys. Furthermore, two of the 15 companies have successfully integrated the Blockchain solution into their businesses; thus, their views strengthen the comprehensiveness of the findings, especially when fruitful adoption of Blockchain in the food industry is relatively scarce.

Table 2. Example of coding for developing concepts and themes.

Illustrative quotes	First-order concept	Second-order theme	Aggregated dimension
We've got a very strong R&D investment programme because innovation and improvement are critical to our future development. A value of our company is recognising the importance of investing in innovation – P1.	Strong R&D investment and infrastructure	Innovativeness	Organisation
We are always at the forefront of innovation; we always want to be at the top of the heap. We don't want to be at the bottom of the heap – P3.	Actively seeking new ideas		
From the start, [the adopting company] was really thrilled about Blockchain … they've already heard about at least Bitcoin or Blockchain technology before, they're also very keen on experimenting with a new idea – P8.	Encouraging trial of new ideas		

4.1. Establishing the process of blockchain adoption

Based on the insights generated through interviews with experts, the process of adopting Blockchain can generally be established with three main phases: Initiation, Adoption, and Implementation. This is consistent with the conceptual framework. Figure 2 summarises the phases and particular activities during Blockchain implementation in the FSC.

During the initiation phase, companies start by recognising a need for Blockchain as a potential solution to overcome challenges in the FSCM. For instance, P1 stated, "*we want to capture as the product moves through the chain. And then, how do we share that with our chain partners; and then, how do we use the blockchain technology to help us do that?*" Once deeming Blockchain worth exploring, companies go through the necessary steps to kickstart their project, starting with identifying the scope and the plan of the project. P7 recalled, "*We started with workshops to do a bit of brainstorming around the scope of the project … frame the problem, identify the scope, timeframes, key contacts, and who else we needed to talk to them, whom we didn't have in that room during the brainstorming workshop*". As Blockchain can be utilised for various aspects of FSCs, a well-defined and achievable scope, even if it is narrow, can help firms maintain their focus during the initial stage of the project and direct the solution to tackle the most prevalent issues faced by the businesses. P1 recalled '*"nsufficient scope at the start cost us 12 months. Initially, we focused on building the temperature logs, but we have other technologies available for that task. After the first 12 months, I moved the focus away from them (the Blockchain service provider) building temperature loggers to look at what is the important information and how do we share it with the help of Blockchain*". Next, a plan for Blockchain implementation is developed, starting with reflecting on the current operation (*to implement any solution, you have to know your supply chain first, so the first thing we do is mapping data, participants, when and where the ownership of the products changes hands* – P2), identifying the starting point (*for our case, products offered for babies from 6 to 8 months are most suitable to offer the Blockchain traceability. We thought this is the right area, and it makes the most sense* – P13), and choosing a suitable Blockchain solution (*after defining the use case, you have to look at different Blockchain networks protocols and decide which protocol makes sense* – P8). A pilot is commonly found as the next step of the project. Piloting Blockchain on a certain product, or a line of products serves as a proof of concept to the company that the technology is a good fit and can provide benefits. This finding is interesting, as several technology implementation models include a pilot as part of the implementation phase, rather than the initiation phase (Kim and Garrison 2010; Pichlak 2016). P2 gave the explanation "*when our clients decide to scale, or to add more volume, or to do their entire supply chain, and this is a more strategic*

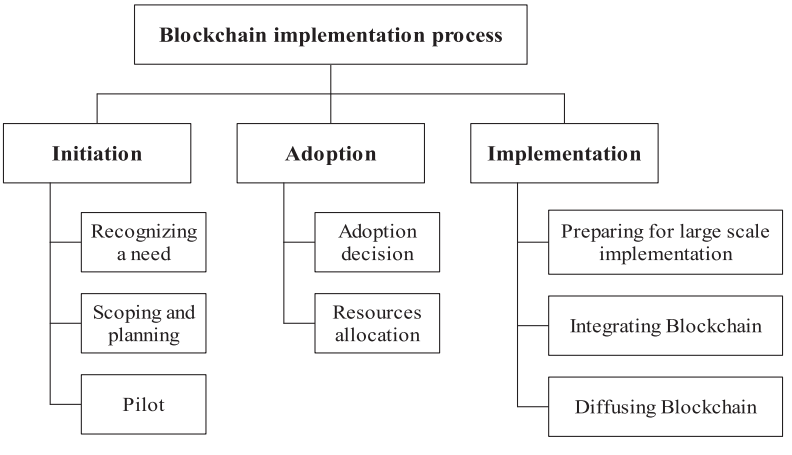

Figure 2. Overview of the process

decision that takes time. To scale, we usually need integration, and for a company to take that decision (a larger investment), they would have wanted to test how the system works first". Thus, in the case of Blockchain for FSC, the adoption stage often begins after evaluating the results from the last step of the Initiation phase, the pilot.

Typically, during the Adoption phase, companies finalise the decision of whether to use Blockchain. The majority of the participants agreed that initial engagement with Blockchain (researching the technology, piloting, etc.) does not necessarily mean the companies will fully commit to implementing the technology. P1 reinstated this point, stating "*We recently completed a three-year project to investigate how Blockchain could improve our supply chains. This included pilot testing of the blockchain technology. We have decided not to proceed with implementing a blockchain at this time as we have other priorities to improve information flow in our supply chains.*". There is one instance where the company fully intends to use Blockchain from the very start. P15 shared "*we had no doubt from the start that Blockchain is a good fit for us. We piloted one line of product for now, but the rest will follow*". However, this notion does not apply to the other companies interviewed. Next, after companies decide to embark on the Blockchain journey, finance, equipment, and human resources investments need to be made. P15 recalled "*The process is the same with the pilot, with a bigger scale. We need to bring in all the relevant departments to work on the expansion of this Blockchain project. It also has to do with investment, as we have to buy more QR code machines for other product lines for example*".

As indicated by experts' insights, the final phase of a Blockchain project is implementation, where companies look to integrate Blockchain into their business and diffuse the use of the technology to other entities in the FSC. Among the participants of this study, P5 and P9 have experience with an end-to-end Blockchain adoption, where the technology has been fully implemented and used in the adopting companies. The first set of activities in the Implementation phase looks to prepare for full integration of Blockchain to the adopting unit, such as further development and modification of the solution, and assign appropriate resources for large-scale deployment. P5 recalled from their project of creating a new financing model enabled by Blockchain for a large commercial farm in Asia "*After the discovery phase and the solution is deemed feasible, we had two banks prepared to work with the system to lend, based on the company due diligence report, and access to the raw data held on the Blockchain. We also did consult and coding for their Blockchain solution*". Integrating Blockchain to the current business is the next logical step, as P9 described "*We successfully integrated Wholechain, our Blockchain solution, in our seafood at scale. It is used in every delivery, not just a pilot or only some product lines*". Lastly, the adopting company aims to diffuse the technology to the network. Insights from participants indicate that the target of this activity is to onboard final consumers and/or direct buyers of the food products with the Blockchain experience. P9, who successfully applied Blockchain at full scale for their business, stated "*for the next step, our focus is on maximising usability for the end-user (end-consumers). So we spend time developing user experiences such as the mobile app for tracking our seafood. This will make onboarding others with Blockchain traceability that much easier*".

4.2. Determinants of blockchain implementation

Determinants of the Blockchain implementation process in the FSC are crucial aspects of building an implementation framework. By understanding them, organisations can better prepare and grasp the projects. Various contextual factors to the process of implementing Blockchain for organisations in the FSC are identified from the analysis of the qualitative data. Guided by the pre-determined conceptual framework, we categorise them into technology, organisation, environment, and management, as shown in Figure 3.

For the technology context, it is found that relative advantages, complexity, compatibility, and cost of Blockchain are relevant to the process of implementing Blockchain. Experts perceived that Blockchain possesses relative advantages over existing IT systems by bringing new values,

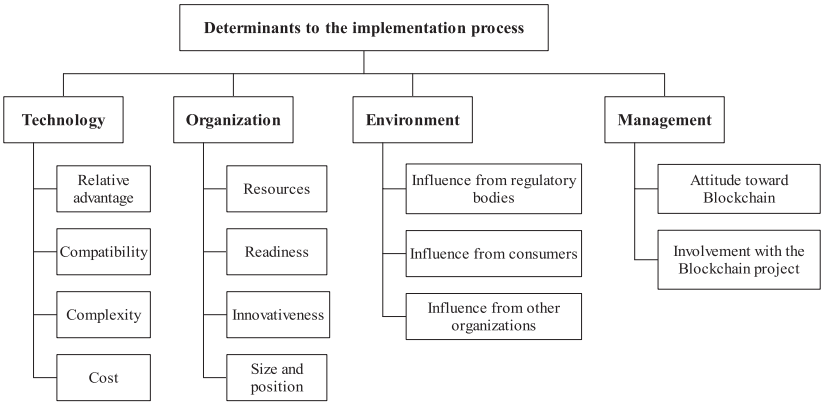

Figure 3. Overview of the determinants of the Blockchain process

improving current processes, and facilitating a more transparent food chain. New values can be interpreted as novel capabilities enabled by using Blockchain. For instance, P5 successfully deployed a Blockchain solution for a novel financing model, enabling their client to have more capital for expanding their farming. P6 further elaborated on the added value that their Blockchain solution can bring to companies "*One thing that we are selling is both visibility and connectivity … By using a public blockchain where all the actors can be connected, you get information from your supplier's supplier's supplier and give to customers' customer all the way to the end customer, and you can open a communication channel all the way to your end consumers and get this interaction with your consumers*". Food recalls are often the example that experts mention while discussing how Blockchain can improve existing processes. P2 theorised how Blockchain could help with the case of an E. coli outbreak due to Romaine lettuce in the US "*for example, the IBM food trust is about having easy access to data on specific shipments. So the famous example with lettuce in the USA, if you have a problem with one, you will not recall everything, because you will know exactly where these problematic containers are coming from*". Other participants highlighted that, with trustworthy information, companies could also look into better inventory management, especially when perishability is a crucial factor for numerous food products. With Blockchain, companies gain trustworthy data on shelf-lives and past journeys of products; thus they can plan to store and transport products, accordingly, assuring the quality and safety of food.

Regarding the transparency enhancement effect of Blockchain, P10 gave an example "*we work with a big brewing company who wants to source the barley directly into their malt houses. They don't want to get their barley mixed up; they want it from certain areas with quality assurance … . They want all that information on the Blockchain system so they can check and award the business to the most honest and trustworthy suppliers*". Compatibility of Blockchain is another essential aspect, as suggested by the interviewees. The technology must align with the adopting unit's needs, goals, processes, and other technologies already in use. P4 warned "*There's very little chance that you'll be able to entirely change the whole process, just for the sake of implementing a new piece of technology. So, it's rather adopting the existing processes and being able to appreciate them and leverage them in the best way possible to get the value*". The interviewees frequently mention complexity, as companies should be conscious of the time and effort needed to master Blockchain. Complexity may arise from the fact that Blockchain is a complex technology, or there are too many solutions to choose from in the market, or from configuring and modifying the solution to fit with the objective; as P7 recalled, "*One of the biggest challenges, we found, was how to scale up the solution in a sustainable way. What is the self-sustaining model for running the Blockchain solution for everyone, and at the same time with low entry barriers for more to join?*" Lastly, the cost is an important factor of

Blockchain that can affect the adoption of the technology. P4 expressed that "*at the end of the day, in the food industry as a whole, the margins are really tight … . so whatever you do, you should not add cost*". P14 also emphasised that, while many solutions have high-end commercial organisations in mind, they recognise that entities with limited financial resources such as farmers are also an important part of the food chain. Thus, the Blockchain solution pricing should take such entities into consideration, and part of P14's solution popularity is attributed to their reasonable pricing. Further, participants highlighted that not only the implementation cost but also the cost associated with running the Blockchain in the future (e.g. fee for storing information on-chain), even though it might be considered small at the moment, should not be neglected.

Findings from the interviews further indicate that resources, readiness, innovativeness, and size and position of the adopting firm are influential to the implementation process. For resources, while the role of financial capability is self-evident, human resources are also essential. P5 shared "*All of the staff there were very young, but they were exceedingly talented people, and that was such an advantage*", showcasing that having skilful people from the adopting company involved is an integral part of their successful Blockchain project. Next, the readiness of a firm for Blockchain can be represented by the existing infrastructure in place for traceability, how capable an organisation is with technology, and a ready-to-change mindset when it comes to technological change. P3 found the integration of Blockchain into their business not too challenging because "*We already have strong traceability technologies and process in place for our aquaculture products. When this Blockchain project presented itself, we knew that we were capable of doing it. Of course, there were some challenges but not too difficult to overcome … we have had over 40 years of being in the aquaculture industry, with experience of implementing many technologies*". P10 further shared that many actors in the food chain, especially in the upper stream of the FSC, are not well equipped to understand advanced information technology such as Blockchain fully, and thus are very hesitant to change, making it difficult for the technology to penetrate such entities – "*they only know running their farms for a long time, still use the same milking process, treat their livestock in the same specific ways for years. So when you start with Blockchain technology, you lose them quickly*". Moreover, the innovativeness of a company plays an important role in starting and advancing the Blockchain project. P1 expressed that "*We've got a very strong R&D investment program because innovation and improvement are critical to our future development*". Other than strong R&D investment and infrastructure, interviewees implied that companies who actively seek for and encourage trials of new ideas are likely to consider Blockchain and advance far with their endeavours. P5 recalled "*during the early development, the fact that they were happy to fail, you know, this is an experience that large companies rarely give us the opportunity to do to experiment and fail is an important part of this Blockchain development*". Lastly, size and position of a firm can also be critical, as per P12's view "*the farmer in Africa cannot dictate to Nestlé to adopt Blockchain. It has to be the management of Nestlé who will ask the farmer in Africa to be onboarded for traceability and visibility for their consumers. That's how it works*". The FSC is typically long and complex, and Blockchain is an inter-organisational solution in nature (Wamba and Queiroz 2022); therefore, initiatives from large enterprises within an FSC can heavily influence others to follow.

The interviewees also recognise influential factors coming from outside the adopting company, suggesting that regulatory bodies, consumers, and other organisations within FSCs can impact the implementation process. The influence of regulatory bodies can come from their encouragement for attempting Blockchain, as well as their tendency to tighten policies regarding food products in the future. Many participants referred to the recent publication from the FDA in the US, in which this agency communicates the demand for more rigorous food traceability in the near future, while also listing Blockchain as an important instrument to facilitate better food provenance (US Food & Drug Administration 2021). On the other hand, consumers can play a critical role in driving companies to consider Blockchain for food products; as P9 commented "*Consumers play an important part in driving Blockchain adoption; you see it in the market and reports. Consumers demand*

trust, with more and more food recalls being more frequent, consumers' demand really is becoming significant".

Further, several interviewees also believed that consumers are willing to spend more for more transparent and safety-proven products. Lastly, other organisations can have an impact on one's Blockchain progress, as the participation from multiple parties is needed for large-scale use of Blockchain, collaborative culture can help speed up the process, and competitive pressure can motivate a firm to embark on the Blockchain journey. P2 recalled "*Our Blockchain-enabled traceability system is end-to-end, and we are usually working with a minimum of two or three connected companies in the supply chain, sometimes even more, to apply our solution to a supply chain*". P7 also shared an interesting observation "*In our project of using Blockchain for tracking meat qualifications, we had three companies, who are also competitors in the market, joined. We start with one company, and it is interesting that, almost like a cascading effect, because the other two knew about that, they wanted to join as well*".

Management characteristics are the last important cluster of determinants inferred from the qualitative data. P11 stated that "*In order to integrate Blockchain into a company, managers have to be ready for the change and also have to be ready to be in charge of such change*", indicating the role of management's attitude toward and during the Blockchain project. Involvement from top managers is also critical to the project. Over numerous projects discussed by the participants, there are three instances where the CEOs of the adopting companies were involved, personally, from the start. Among these three cases, two CEOs (P13 and P15) participated directly in this study. P15 recalled "*To start the project we needed to connect all departments in the companies. We were involved in meetings regarding granular details such as what to upload, what data to share, timing, etc. There is overall a great deal of involvement from the management of the company in the project*". In turn, these projects have had various degrees of success, ranging from successful pilots to full adoption of Blockchain.

5. Evidence-based blockchain implementation model and implications

In this section, first, the empirically validated and revised model for Blockchain implementation is presented. Later, the theoretical and practical implications of this study are discussed.

The initial conceptual framework described in Section 2.2 provides a good starting point to grasp how Blockchain technology would unfold at the organisational level within the FSC setting. Based on the findings drawn from the semi-structured interview data, the conceptual framework was validated and further improved to capture the overall process of implementing Blockchain for companies in the food industry, along with the main determinants of such a process. The end product is an empirically driven and practical model for Blockchain implementation in the FSC, as presented in Figure 4. Consistent with our thinking, a purely conceptual framework cannot fully be aligned with the phenomenon in practice; thus there are noticeable changes/ upgrades between the conceptual framework (see Figure 1) and the final model (See Figure 4). At a glance, the main phases of implementation remain the same in the final model. However, the pilot activity is now moved to the Initiation phase. As can be seen for P15, P13, and especially P1 (where the company halted the decision of using Blockchain after the pilot), companies would conduct a pilot of using Blockchain for food products before making a definitive decision of committing to use the technology.

Further, learning from the experience of P5 and P9, the last step in implementing a Blockchain solution is onboarding other stakeholders to the system. As suggested by the initial conceptual framework, the implementation phase would typically stop after the innovation is incorporated into the organisation's structure (Hameed, Counsell, and Swift 2012; Pichlak 2016). However, the case of Blockchain could differ, as the technology would provide greater benefits if it can be adopted across the supply chain network (van Hoek 2019); thus, the necessary activity after successful implementation in one organisation, would be to connect other entities to the Blockchain system. The changes to the activities within each implementation phase are captured in the final evidence-based model shown in Figure 4.

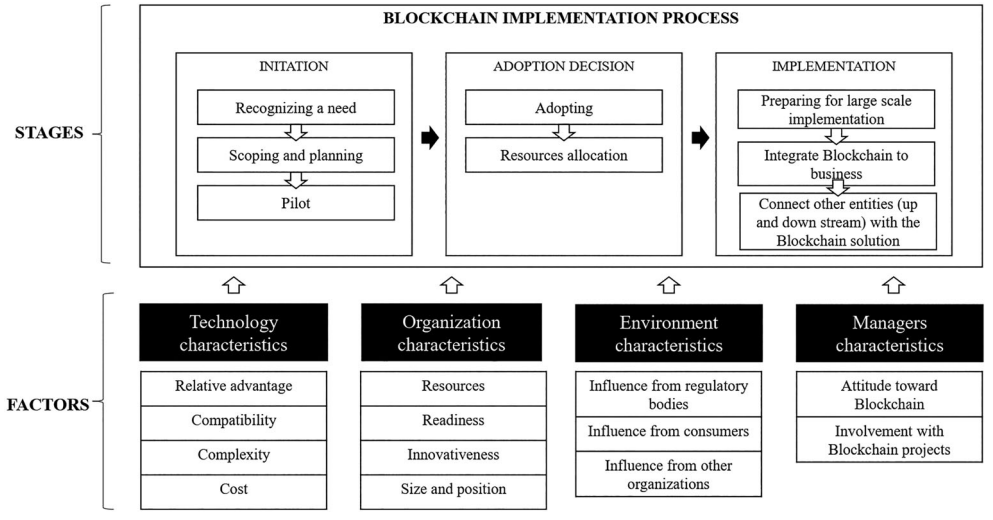

Figure 4. Evidence-based framework for implementing Blockchain in FSC.

Moreover, insights from the interviews are useful in expanding the conceptual framework, especially in determining determinants of the implementation process of Blockchain. The conceptual framework identifies four general clusters of technology, organisation, environment, and managers characteristics. However, the literature has identified numerous factors that could feature in each category (for a comprehensive list of potential factors see Hameed, Counsell, and Swift 2012 or Pichlak 2016). Insights from the interviews help discover the most relevant determinants in the case of implementing Blockchain in the FSC setting. For example, consistent with what DoI suggested, interviewees found relative advantage, compatibility, and complexity of Blockchain technology to be critical in the process of adopting Blockchain. DoI also proposed that trialability – '*the degree to which an innovation is perceived as possible to learn by doing*', and observability – '*the degree to which the results of an innovation are visible to others*' (Pichlak 2016, 481), were not highlighted by interviewees. Findings from the interviews also pointed to an additional determinant, the cost of Blockchain, as an important influential factor in the process of integrating the technology into organisations, which is understandable as "*margin is tight for the food industry as a whole*" (P4) and "*to onboard people such as farmers or co-operatives the cost of the Blockchain solution must be competitive*" (P14). Following the same approach of contrasting insights from interviewees to the literature, other factors, that experts view to be pertinent to the specific setting of FSC are uncovered for the other three main groups of determinants – organisation, environment, and management. Organisational factors include resources, readiness, innovativeness, and size and position. Regarding environmental factors, influences from regulatory bodies, consumers, and other organisations in the food chain were considered important by interviewees. Finally, it was evident that the attitude toward Blockchain adoption and the involvement of the top managers during the project are two critical determinants under the managers' characteristics cluster. Overall, qualitative data provided in-depth insights to bridge the gaps between a conceptual framework and an evidence-based model for Blockchain implementation in the FSC.

5.1. Theoretical implications

Findings from this study contribute to the extant literature in two ways. First, this study advances the literature on SCM in the wake of Industry 4.0 developments, providing an in-depth

understanding of the implementation process by which Blockchain is integrated into organisations for better management of the supply chain. As discussed earlier, the majority of existing studies were interested in the constitutional factors to the adoption decision/intention of Blockchain in the area of SCM. However, this study expands current thinking by exploring another facet of technology adoption, providing the comprehensive life cycle of the Blockchain from initiation to the point of full integration. Thus, this study responds to several calls for empirical research on Blockchain implementation in a specific industry setting (van Hoek 2019; Wamba and Queiroz 2022). Further, our study emphasises combining contextual empirical evidence with the extant understanding of innovation adoption to develop a pertinent and specific model of Blockchain implementation in the food industry. This is different from the conventional approach of examining literature to identify relevant determinants to the adoption process theoretically, then validating with empirical data, which has been employed commonly to study other technology (e.g. Hossain, Quaddus, and Islam 2016; Martins, Oliveira, and Thomas 2016) including Blockchain (e.g. Wamba and Queiroz 2022).

Second, this study offers an elaboration approach to advance the IA body of literature by bridging the general theories and concepts of the innovation adoption concept to the specific context of Blockchain in the FSC. Theory elaboration can be a strong approach to applying an existing general theory to a setting that is not well-known, deducing useful premises and testable hypotheses (Ketokivi and Choi 2014). In this regard, several propositions can be developed and tested using quantitative methods in the future.

Third, this study utilises a qualitative approach to assess and improve the adoption process of new technology, thus advocating the use of qualitative methods in exploring the phenomenon of novel technology, especially when the current body of literature is under development.

5.2. Managerial implications

Several implications for practitioners in the FSC can be drawn from the implementation model proposed in this study. First, the model suggests a comprehensive and practical approach to adopting Blockchain. Valuable lessons can be learned from the experience of early adopters who participated in this study. For instance, Blockchain should only be considered when there is an actual need for the technology. Blockchain is not a silver bullet to all challenges in FSC (Kumar et al. 2020). However, when companies perceive a critical challenge, such as the need to communicate information regarding food provenance and quality in a trustworthy and secure manner, Blockchain could be a promising solution. At the beginning of the project, the adopting company needs to spend considerable time understanding the technology and their SCM processes. Nevertheless, the objective of the project, and the use of Blockchain for the company, must be extremely clear to set the course correctly for the rest of the project. Furthermore, a pilot is highly recommended to test the suitability and capability of the technology, and the adopting company needs to be aware of what is required to progress the technology further.

Second, the opinion from industry experts about the most important and influential factors to the integration of Blockchain in the FSC is captured and embedded in our model. Thus, an evidence-based model could be useful in suggesting to managers what determinants could arise due to special characteristics and conditions of the food industry and how they could potentially shape the Blockchain project. For instance, the degree of readiness for advanced technology such as Blockchain is critical, as companies with already robust processes of food traceability can find the adoption of Blockchain considerably straightforward. Readiness and technological know-how can also be crucial for the expansion of Blockchain within a network of food actors, as actors in the upstream food chain can have noticeable resistance to implementing the technology. Further, in the specific context of FSC, organisations can expect that major sources of motivation and pressure to explore Blockchain come from consumers and regulatory bodies, as most of the interviewees saw a significant rise in the end consumers' demand for more trustworthy information

about their food products at and after the point of purchase and believed that traceability of food products in the near future would be under much stricter scrutiny. Under the same vein, other FSC-relevant determinants included in our final models (with the discussion of what they mean in the context of the food industry in Section 4.2) can also be helpful for managers in the field to anticipate influential factors and possible challenges, achieving a smooth and successful integration of Blockchain. Understanding how a technology assimilates at an organisational level is critical to obtaining successful implementation and realising business values from the technology (Zhu et al. 2006).

6. Conclusion

The objective of this paper was to develop a practical model of implementation for Blockchain technology in the context of the FSC. First, building on previous work (Vu, Ghadge, and Bourlakis 2021) and drawing from relevant IA theories and models, a conceptual framework was developed for Blockchain implementation in the FSC. After collecting and analyzing the empirical data, this framework was improved into an evidence-based and practical model, including three main phases of adoption and four determinant categories of the process. From the results, it is established that Blockchain unfolds through the phase of Initiation (where the adopting company recognises a need for the technology, defines the scope and plan for the implementation, and runs a small scale pilot), Adoption (where the adopting company makes the final decision of whether to adopt Blockchain, and assign sufficient resources if so), and Implementation (where the adopting company makes the necessary preparations for large scale adoption, integrates the technology to the business, and diffuses it further into other relevant entities such as consumers and partners). Moreover, it is also identified that influential factors for four validated determinants of the Blockchain implementation in the FSC comprise: relative advantages, compatibility, complexity, and cost (Technology), resources, readiness, innovativeness, and size and position (Organisation), influences from consumers, regulators, and other organisations within the FSC (Environment), and attitude and involvement from top managers (Management).

Validation and improvement of the implementation model are based on a limited number of semi-structured interviews. As with all qualitative research studies, the limitation of this study lies in its ability to generalise the results to a broader setting. Nevertheless, the knowledge obtained from this study can be of importance when planning the implementation of Blockchain under similar circumstances. Moreover, the findings are largely inferred from the view of the respondents. Thus, biases might exist, even though interviews were conducted carefully to gather exact facts and insights about the Blockchain projects, and questions were asked in a way to minimise subjective answers. Another limitation of this study is that the results are very context-specific – FSC in this case and may be difficult to generalise.

Following the results of this study, many exciting future research directions are recommended. Literature has identified a lack of quantitative studies in this domain (van Hoek 2019); thus, quantitative studies including simulation, can be used to validate and generalise this study's findings. A potential direction for quantitative research is to determine the impacts of determinants on the process of Blockchain adoption. Although the final model suggests various determinants to the process of implementing Blockchain for FSC, the impact of a particular determinant (such as technology advantage or the organisation's readiness) might vary between different phases of adoption, and statistical tests are more suitable to uncover such insights. Furthermore, it can be observed that practitioners have achieved a certain degree of success in implementing Blockchain. Given the rapid development of Blockchain in the FSC, an in-depth examination of Blockchain implementation projects could further uncover specific and valuable insights, such as how the system is configured and/or governed. Therefore, case studies are highly recommended as promising future research avenues to continue expanding the current knowledge about Blockchain adoption.

Moreover, studies attempting to combine Blockchain with existing information systems (e.g. ERP, WMS) or other Industry 4.0 technologies (e.g. IoT, AM) would provide more opportunities

to explore the robustness of Blockchain technology. Future research attempting to identify skill requirements to adopt disruptive/novel technologies is expected to further benefit SC practitioners. Empirical research with quantitative approaches is recommended to validate our findings. Finally, although this study proposes a pertinent model of Blockchain implementation in the context of FSC, further advancements of the model at a more granular level can be considered. Particularly, future research can use our model as a foundation to explore how various entities in the food chain could approach Blockchain implementation and uncover the differences depending on the position of the entities.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The data that support the findings of this study is available from the corresponding author following a reasonable request.

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Appendix A – Interview protocol

Section	Question
Introduction	Interviewer confirms the name and position of the interviewee, asking for necessary permission such as recording.
	Could you briefly describe the Blockchain project which your company is/was undertaking?
Process related questions	I would like to know more about the phases and activities, which often take place in a Blockchain project. From your own experience, what was the first activity you do to set off the project? And after that? What was the most current activity that has been done?
Factors related questions	In your opinion, what are some of the influential factors to this project?
	What are some factors/ elements that makes the process of this project faster/ easier, or more difficult?
	What are some of the challenges when applying Blockchain for food chain?
	How would you rate the role of managers in this Blockchain endeavour?
Closing the interview	(If there are some points which the interviewer needs to be clarified or confirmed)About … , could you please elaborate … .
	If possible, could you please introduce me to someone who is willing to participate in this research, who has had similar experience like yourself?

Appendix B

Illustrative quotes	First order concept	Second order theme	Aggregate dimension
The traditional chains are actually fragmented and not collaborative. The traditional chain is actually transactional based, and that absolutely constrains the capacity to actually improve the chain. With Blockchain, we're trying to have a paradigm shift where we go from companies holding information to actually sharing it – P1We started, roughly around 2011, working with a cooperative that was offering organic meat products to the market. There was not a way of efficiently communicate that there's a story behind this product, versus maybe some other product with might have come through a more intensive farming practices, or more of what we consider like factory meat. So we were looking at deploying a decentralised network of information, leveraged by Blockchain, for visibility, extermination of data silos, and defragmenting the whole supply chain network – P4	Recognising a need for Blockchain	Initiation phase	Process
we start off with workshops really inception workshops to do a bit of brainstorming around the scope of the project, say what is achievable, what are your burning questions that we want to tackle and do a bit of prioritisation exercises with them. Frame the problem identify the scope timeframes, key contacts, and who else we needed to talk to them, we didn't have in that room – P7.In the first 12 months of the project we let [service company] do what they want, and we did not learn a thing. After 12 months of working on the Blockchain project, I said to the [service company] that there was no need for you to develop temperature logs as we have the technology available. I moved the focus away from them building temp loggers and tracking temperature to know what the important information is, how to capture it, and how to share it with chain partners with the help of Blockchain – P1the first thing we do is we support with the data mapping and the participants mapping so first to understand who is involved, who is doing what. When does the ownership of the products change hands what places, because that will also influence what data, who is to upload so we have to know that first so map out the supply chain, the participants? And then we also support in mapping out the data so understanding what details, do we need in what format are those in other existing systems do we have to work with simplified uploads. So that's the basically the first step to get started – P2.	Scoping and planning		
We made a pilot project last year last summer, with the halibut producer and distribution companies and slaughterers and all the way out to sushi restaurants. So we could track everything. We do it in in smaller incremental steps so starting with a small pilot showing that we can actually prove something we can do something. And then start integrating with iot sensors and you start integrating with the production system under ERP system, and so on – P6.	Pilot		
when they decide to e.g. scale to more volume or to do their entire supply chain this is a more strategic decision that takes time. After the pilot, there is usually an evaluation of the process and outcomes that lead to the decision to continue with the scaling (usually to more supply chains and more volumes). The point is therefore usually at the end of the pilot when they've tested the capacity of the system. To scale, we usually need integration, and for a company to take that decision (a larger investment) they would have wanted to test how the system works first – P2	Comes after evaluating the results of the pilot	Adoption decision phase	
After the discovery phase and the solution is deemed feasible, we had two banks prepared to work with the system to lend based on the company due diligence report, and access to the raw data held on the Blockchain. We consulted, did some coding for the company, but it really became their solution – P5	Preparation for large scale implementation	Implementation phase	
We successfully integrated Wholechain, our Blockchain solution, in our seafood at scale. It is used in every delivery, not just a pilot or only some product line – P9	Integrating Blockchain		
And in the other end if we thank my farmer consumer APP. It is a progressive web APP and there is really where consumer can see more information around their product see map that is powered by blockchain, where consumers can either learn more and understand what projects that are implemented in those communities and also where they want to, they can follow those and even support with a financial. That's the end-to-end system – P2	End user engagement		

One thing that we are selling is both visibility and connectivity, so companies today normally only have one tier up and tier down of information flow, you only get information from your first supplier, and you give it to your customer. By using a public blockchain where all the actors can be connected, you get information from your supplier's supplier's supplier and give to customers' customer all the way to the end customer, and you can open a communication channel all the way to your end consumers and get this interaction with your consumers – P6	New values can be added using Blockchain	Relative advantage	Technology
We work with a big brewing company who wants to source their barley directly into their malt houses. They don't want to get their barley mixed up, they want it from certain areas with quality assurance, biosecurity, compliance with chemical use and chemical residue. They want all that information on my Blockchain system, so they can check chronological hashing order to award the business to the most honest and trustworthy suppliers – P10	Facilitating a more trustworthy and transparent supply chain		
frictionless trade is a big thing for companies. one of the big drivers for the HMRC wine pilot is to see how it can link up with existing systems to you know offer that friction is trade perspective. So that if you are, for example, you're providing all the information, maybe it's an easier way to you know sign off those consignments – P7	Improving current process such as reducing time and increasing efficiency		
The Blockchain idea started when we were looking at securing data points for the quality measures in the meat red meat industry. There is no quality read on lamb, for example, and that is an issue. And securing those data points about red meat quality, is a natural home for Blockchain with the privacy and security – P10	Blockchain should align with the need and goal of the organisation	Compatibility	
There's very little chance that you'll be able to entirely change the whole process, just for the sake of implementing a new piece of technology so it's rather adopting to the existing processes and being able to appreciate them and leverage them in the best way possible to get the value – P4	The use of Blockchain should correlate with the current process		
we were working with the different systems in food supply chains you're touching different IT vendors different systems, different file formats different or everything's different for anything from an excel file to a customed ERP/SAP and Oracle and Microsoft right. So interoperability of the Blockchain solution is to enable more fluent communication between the systems – P4	Blockchain should be able to integrate with current system/ technology		
We have a lot of discussions that are underway. But if I'm asked to put it, I would still view Blockchain as definitely being at education phase. People are still getting their heads around it and trying to figure out – P10	Blockchain is still a novel concept to business, so it takes time to grasp the technology and its use.	Complexity	
Private, public, and hybrid solutions of Blockchain are different, and are chosen depends on who we are onboarding on our solution. There are different solutions, depending on different group of use cases how we see the market being matured – P12	Many solutions to choose from		
One of the biggest challenges, we found, was that how to scale up the solution in a sustainable way. What is the self-sustaining model for running the Blockchain solution for everyone to sue, and at the same time with low entry barriers for more to join – P7	Difficulties in configuring and tailoring the solution to fit the business		
Because, at the end of the day, food industry as a whole it's a very the margins are really tight yeah so whatever you do, you should not add cost – P4We focused on small holder farmers; our price point is very competitive. There are a lot of solutions that just want to focus on high end commercial whereas ours is for everybody and relatively inexpensive, so farmers love us – P14	Cost of implementing Blockchain is influential	Cost	
You have to be mindful of the cost of storing data on Blockchain because in the supply chain there is a lot of information generated. So you have to get a balance of the speed of authenticating the data, and the cost of doing so – P1	Cost of running and maintaining the solution is influential		
One type of investment in this kind of project, Blockchain, is providing money – P1	Organisation needs sufficient fund for the Blockchain project	Resources	Organisation
All of the staffs involved in the project were very young, but they were exceedingly talented people, and that was such an advantage – P5	Capable people on the project are an advantage		
For some companies, they are very much set up. They have systems in place, data is already standardised across, so it is very easy to work with them on the Blockchain project. In other places it's really scattered, certain companies in some countries have paper records still, and when that happens it's a difficult starting point – P2	Organisation with better traceability infrastructure finds Blockchain implementation less challenging	Readiness	
When this Blockchain project presented itself, we knew that we were capable of doing it. Of course there were some challenges but not difficult to overcome. The Ecuadorian shrimp farming industry is very matured, and we have had over 40 years of being in the industry, with experience of implementing many technologies – P3	Adoption is easier when organisation is technologically capable		
People do not like change. When we discuss Blockchain, some stakeholders loved it, and others were negative about it. It is a big issue because people sometimes are caught up with the old thinking of 'he who owns the data will role the world of information', so Blockchain with connectivity and data sharing scares them – P10	Ready to change mindset is needed in an organisation		
We've got a very, very strong R&D investment programme because innovation and improvement are critical to our future development. A value of our company is recognising the importance of investing in innovation – P1.	Strong R&D investment and infrastructure	Innovativeness	
We are always at the forefront of innovation; we always want to be at the top of the heap. We don't want to be at the bottom of the heap – P3.	Actively seeking new ideas		
From the start, [the adopting company] was really thrilled about blockchain … they've already heard about at least bitcoin or blockchain technology before, they're also very keen on experimenting with new idea – P8.	Encouraging trial of new ideas		
the farmer in Africa cannot dictate Nestle to adopt blockchain. It has to be the management of Nestle who will ask the farmer in Africa to be onboarded for traceability and visibility for their consumers. That's how it works – P12	Organisation with more resources and commanding power in the network should be driving the project	Size and position	

(*Continued*)

Continued.

Illustrative quotes	First order concept	Second order theme	Aggregate dimension
An example is the the US government's FDA has new era of smarter, food safety report and in the FCC regulations, Section 2040, they have actually listed down few products that will be required to provide the end-to-end traceability (cheese, milk, etc). So those companies who are operating in those food chain, because of regulations, are pushed to adopt or apply blockchain because blockchain was mentioned in that regulation as well. So when I come to them, I don't have to explain a lot and already get the welcoming attitude – P12	Policies regarding food will be tighten, drive business to use Blockchain	Influences from regulators	Environment
Five projects that P1, P3, and P7 were involved with are directly funded by the governments	Encouraging the use of Blockchain from regulators		
Consumers play important part in driving Blockchain adoption, you see it in market and reports. Consumers demand for trust, with more and more food recalls being more frequent, consumers' demand really is becoming significant – P9	Consumers' demand pushes companies to use Blockchain	Influences from consumers	
It is the food that we are consuming, so if there is that little bit extra to make sure that they will be more secured, people are willing to pay it – P10	Consumers are willing to pay more for transparent products enabled by Blockchain		
Our Blockchain enabled traceability system is end to end, and we are usually working with minimum of two or three connected companies in the supply chain, sometimes even more, in order to apply our solution to a supply chain – P2	Blockchain solution needs participation from other organisations in the supply chain	Influences from other organisations	
Fundamentally it is a change in paradigm, in thinking, in the attitude of the businesses in the chain. So you really need the businesses to have a collaborative culture, where they are willing to participate and work together as a whole chain – P1	Collaborative culture in the supply chain is an advantage for implementing Blockchain		
For one of our projects, we had three companies, who are also competitors in the market, joined. We start off with one company, and it is interesting that, almost like a cascading effect, because the other two knew about that and wanted to join as well – P7	Competitive pressure drives companies to adopt Blockchain		
In order to integrate Blockchain into a company, managers have to be ready for the change and also have to be ready to be in charge of such change – P11	Management shows willingness to embark on the Blockchain journey	Attitude from managers	Management
When working with the client for the Blockchain pilot, there wasn't any negativity or concerns from top management. And I think that creates a healthy working environment – P8	Management is supportive throughout the project.		
Managers in companies we work with are not involved in day in day out of the project. But they are definitely aware of the progress. And it is a strategic decision to go towards digitalisation, technology, traceability, and responsible sourcing, and it is really a management decision – P2	Management actively participates on formulating strategies and visions of using Blockchain	Involvement from managers	
We are actually seeing a really good amount of senior level managers involved, and that is really encouraging because ultimately it is them who have to drive the project and lead their organisation in adopting Blockchain – P9	Management presence during the project is encouraging		