Implementing Blockchain in the food supply chain: An empirical study.

Nam Vu[1*], Abhijeet Ghadge[2], Michael Bourlakis[3]

[1*]Cranfield University, School of Management, United Kingdom, nam.vu@cranfield.ac.uk

[2]Cranfield University, Centre for Logistics and Supply chain Management, School of Management, United Kingdom, Abhijeet.Ghadge@cranfield.ac.uk

[3]Cranfield University, Centre for Logistics and Supply chain Management, School of Management, United Kingdom, m.bourlakis@cranfield.ac.uk

1. Introduction

In recent years, Blockchain technology has gathered significant interest from both managers and researchers in the area of the food supply chain (FSC). Fundamentally, Blockchain is a distributed ledger technology which can store and share information in a decentralized, secure, and trusted manner (Wong et al., 2020). Anticipated to have the potentials to solve critical challenges in food supply chain management (FSCM) such as end-to-end traceability, information asymmetry, and low level of visibility, Blockchain has seen increasingly uses in the food industry (Zhao et al., 2019). A number of notable examples include Carrefour using Blockchain for poultry product range (Food blockchain | Carrefour Group, 2020), and Walmart piloted Blockchain for tracking mangoes and pork (Hyperledger, 2019).

The literature on Blockchain technology in the context of FSC has also seen significant growth in the past few years, exploring various aspects such as applications, drivers, barriers, and adoption (Zhao et al., 2019; Vu et al., 2021). Among few studies that addressed the adoption of Blockchain (i.e. Queiroz and Fosso Wamba, 2019; Wong et al., 2020), the focus is often on the single-stage where the decision of adopting Blockchain is made. When studying the adoption of new technology, understanding the pre-adoption steps (i.e. assessing the suitability of the technology) and the post-adoption steps (i.e. deploying the technology at the organizational level) is crucial to successfully adopt a new technological innovation to generate values (Zhu et al., 2006; Martins et al., 2016). Therefore, this study seeks to answer the question “How to implement Blockchain for organizations in FSC?". While attempting to answer the research question, this study found that the process of adopting Blockchain at the organization level typically unfolds over three main phases Initiation – Adoption – Implementation, and the main determinants to such process come from the Technology – Organization – Environment – Management contexts. Thus, the contribution of this paper is twofold. First, it provides a holistic view of the end-to-end Blockchain implementation process in FSC, with specific activities and influential factors. Second, this study proposes an evident-based framework for implementing Blockchain in the FSC, proving a practical reference for managers in the field when considering the use of Blockchain.

2. Background to the research

The body of literature regarding the adoption of innovation is vast, with various theories and models. It is argued that relying on a single theory might not be sufficient to reflect and understand the increasingly complex phenomenon of today’s technology adoption (Wamba and Queiroz, 2020). Hence, integrative models – using more than one theoretical perspective – are often utilized in examining the implementation of technology (Zhu et al., 2006; Martins et al., 2016; Kamble et al., 2020; Wamba and Queiroz, 2020). Hence, this study followed the same strategy in developing the conceptual model for Blockchain implementation in FSC. In this study, innovation and technology are used interchangeably, when referring to the Blockchain technology.

A stage model is often used to examine the implementation of new innovation at the organizational level. Diffusion of Innovation (DOI) theory by Rogers (2003) proposed five phases for

diffusing an innovation: knowledge, persuasion, decision, implementation, and confirmation. Recent studies, based on the principles of DOI, often suggested a three-stage model to capture the activities before, during, and after the decision of adopting new technology: Stage 1 Initiation – the organization recognizes a need for the technology, gathers more knowledge, and proposes a plan for the adoption, Stage 2 Adoption – the organization makes the decision of adopting and allocates necessary resources for the adoption, and Stage 3 Implementation – the organization runs a pilot, modifies and deploys the technology at a larger scale, and carries out post-implementation activities (i.e. training, routinizing). Further, prominent theoretical perspectives such as Technology – Organization – Environment (TOE) framework (Tornatzky et al., 1990) and DOI (Rogers, 2003) can outline the determinants to the process of Blockchain implementation. In TOE, technology context refers to the characteristics of the technology being adopted, organization context indicates the descriptive measures (e.g., size and scope) and attributes (e.g., resource and infrastructure) of the adopting unit, and environment context includes external factors such as industry, regulations, market (Hameed et al., 2012; Martins et al., 2016). Lastly, several researchers stress the importance of management in the process of implementing new technology, thus advocating to consider management characteristics as a cluster of determinants with equal standing as technology, organization, and environment characteristics (Damanpour and Schneider, 2009; Hameed et al., 2012). Drawing from the literature reviewed previously, the conceptual model for Blockchain implementation in FSC was developed as depicted in Figure 1 (Refer to Vu et al., 2021 for more information).

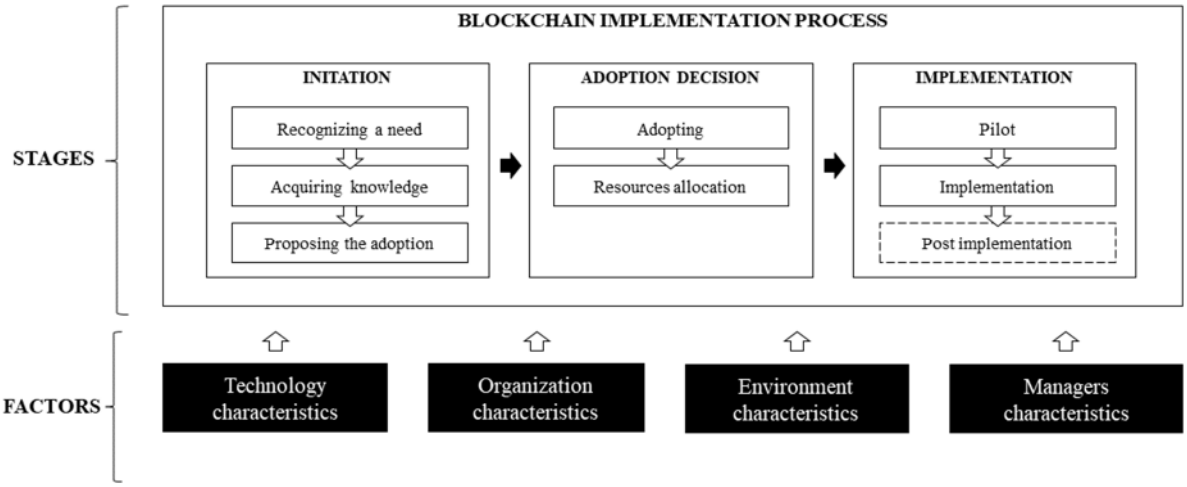

Figure 1. A conceptual model for Blockchain implementation in FSC (from Vu et al., 2021).

3. Methodology

Qualitative research was conducted, with semi-structured interviews being the main instrument for data collection. The motivation for employing a qualitative approach was to obtain rich and specific insights from industry experts to bridge the literature with the context for an in-depth and explicit understanding of the implementation of Blockchain for FSC.

A total of 13 semi-structured interviews were conducted. First, the authors examined public sources (i.e. news, industry reports, etc.) to develop a list of companies in the food industry, who have initiated/piloted Blockchain. A letter of invitation was sent to individuals from those companies, who have been directly involved with the Blockchain adoption projects. Potential candidates from 45 companies were contacted, and 13 agreed to participate (see Table 1 for generic description), resulting in a 28% rate of response. An interview protocol, with open-ended questions about typical activities of a Blockchain project and associated influential factors, was developed and agreed upon among the authors. Furthermore, the first three interviews also served to validate the relevance and clarity of the questions. Certain insights from these interviews were relevant to answer the research

questions, thus the data was included in the analysis. Most participants gave consent to record their interview. One participant did not provide permission, thus the interviewer took notes for the main points of the interview and validated those with the interviewee later. A transcription was automatically created by the online interview platform – Zoom, then was verified with the audio recording for any correction, and finally was used for the data analysis.

Participants (P)	Type of organization	Position	Experience
P1	Fruit producer	Quality manager	15+ years
P2	Blockchain service provider	Business development manager	2+ years
P3	Seafood producer	Sale executive	10+ years
P4	Blockchain service provider	General manager	5+ years
P5	Blockchain service provider	CEO	20+ years
P6	Blockchain service provider	Founder & CEO	20+ years in technology adoption, 4+ years in the food industry
P7	Food regulator	Project manager	5+ years
P8	Blockchain service provider	Project manager	2+ years
P9	Seafood reseller	Founder & CEO	10+ years
P10	Blockchain service provider	Founder & CEO	5+ years
P11	Consulting service	Senior consultant	10+ years
P12	Blockchain and software service	Director of emerging technology	10+ years
P13	Processed food	Founder & CEO	4+ years

Table 1. General information about the participants.

4. Analysis and findings

Coding was the method of choice to analyse qualitative data from the interviews. Nvivo 12 software was used to aid the coding process. First, a segment of the data – often a sentence or a coherent set of statements – is assigned with a relevant concept. Then, related concepts are grouped under a more abstract first-order concept. First-order concepts are subsequently categorized under a relevant context - a second-order theme. Literature on innovation adoption was utilized 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 one (theme and/or categories). Due to the limited length of this conference paper, an example is given to illustrate this coding process. Table 2 illustrates how the specific concept of the organization's innovativeness, part of the organization context, was induced from the qualitative data.

Illustrative quotes	Concept	First-order concept	Second-order theme
We've got a very, very strong R&D investment program because innovation and improvement are critical to our future development. A value of our company is recognizing the importance of investing in innovation – P1.	Strong R&D investment and infrastructure	Innovativeness	Organization
We are always at the forefront of innovation, we always want to be at the top of the heap.	Actively seeking new ideas		

We don't want to be at the bottom of the heap – P3.			
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		

Table 2. Example of coding.

Drawing from the interviews, a general view of the step-by-step process for adopting Blockchain and four main categories of determinants to the process are obtained. This process and determinants closely reflect the phenomenon of implementing Blockchain in the specific setting of FSC. The following sections will discuss the findings in detail.

The process of adopting Blockchain in FSC

Similar to what the literature suggested, Blockchain typically unfolds in organizations in FSCs over three main phases: initiation, adoption, and implementation. For the initiation phase, firms typically started with recognizing a need for Blockchain as a potential solution to some persistent challenges in FSCM. P1 recalled, "*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 to do that*". After deeming Blockchain as a suitable solution, firms determine the scope and the plan for the project. Identifying a specific scope helps the organization to set appropriate objectives and a roadmap for the implementation. P7 recalled, "*We start off with workshops to do a bit of brainstorming around the scope of the project… to say what is achievable, what are your burning questions that we want to tackle*". On the other hand, planning is to set the stage for Blockchain implementation by analysing the current supply chain and determine important elements such as suitable solutions, parties involved, data point to be captured, etc. P2 described the activity as "*to implement any solution in the supply chain, you have to know your supply chain. The first thing we do is we support with the data mapping and the participants mapping. It is important to understand who is involved, who is doing what, when does the ownership of the products change hands, and at what places? So the activity is to map out the supply chain*". Following the scoping and planning step, the next activity is conducting a pilot of Blockchain adoption. This finding is interesting since the experts' insights are different than what the literature suggested. In a number of adoption models, a pilot is often found to be included in the implementation phase rather than initiation (Kim and Garrison, 2010; Pichlak, 2015). For the case of Blockchain for FSC, the final decision of using Blockchain comes after the pilot, and subsequently, the results of such pilot can dictate the decision of fully adopting Blockchain.

There are two instances in which the participants successfully integrated Blockchain into their organization and operation. Thus, insights regarding the implementation phase of Blockchain project were acquired. One important finding is the orientation of activities related to diffusing the technology at the individual level. Since Blockchain is an underlying technology added on top of existing IT systems and processes, it brings minimal changes to employees' daily tasks. The targeted end-users in this case are often the end consumers and/ or the direct buyers of the food products, as organization aims to onboard them with the Blockchain experience. P9, who successfully integrated Blockchain for their business, shared that "*for the next step, our focus is on maximizing usability for the end-user (end-consumers). So we spend time to develop user experience such as the mobile APP for tracking our seafood. This will make onboarding others with Blockchain traceability that much easier*". The other main activities for this phase are preparing the solution for large-scale deployment and integrating Blockchain into the organization's operation and business.

The determinants of the Blockchain implementation process in FSC

Relevant determinants of Blockchain implementation in FSC are found from experts' insights. These factors can be categorized into four clusters: technology, organization, environment, and management characteristics.

For the technology context, it was 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 and improving current processes. New values can be interpreted as novel capability/ business 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. Food recall is often the example that experts mentioned when discussing how Blockchain can improve existing processes. P2 theorized how Blockchain can help with the case of the 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*". The complexity of Blockchain is also perceived as an important factor to the implementation. Especially during the pre-adoption activities, participants expressed challenges in choosing the right solution, configuring different parameters of the system to synchronize with current operation, and identifying how to scale the system sustainably for large operations with numerous parties involved. Part of the complexity is because Blockchain is still novel to the food industry and more efforts from early adopters are needed to understand and develop the solution – as P10 said "*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".* Compatibility is another aspect that was highlighted by the participants. Firms are keen to embark on the Blockchain journey when they perceive it to be consistent with the existing values and needs. Extant literature also stressed that being able to integrate with the current process and IT infrastructure is a key for a new technology to integrate into an organization successfully (Martins et al., 2016). Lastly, the majority of participants agreed that the cost of Blockchain should factor into the decision of using it. Cost is recognized as an influential factor to innovation adoption (Hameed et al., 2012), and even more so in the food industry setting, as emphasized by P4 "*at the end of the day, food industry as a whole, the margins are really tight. So whatever you do, you should not add cost*".

Insights from participants unveiled that resources, readiness, innovativeness, size and position of an organization are influential to the process of Blockchain implementation in FSCs. In terms of resources, both financial and human resources need to be sufficient for the Blockchain project. The importance of finance is self-evident, and human resource is just as important to the implementation process. P5 attributed part of the success of their Blockchain project to having the right personnel from the adopting company involved "*All of the staff there were very young, but they were exceedingly talented people, and that was such an advantage*". Readiness can be indicated by having the necessary technological capabilities and experience with using/ adopting IT systems. For instance, with the case of P3, determining the critical data point and having that information ready for their Blockchain-enabled traceability project were straightforward because "*traceability for us is nothing new. We've had this requirement for many years before by customers*". Innovativeness is an interesting concept that participants brought up when discussing what enables firms to adopt Blockchain smoothly. Innovativeness of a company can be demonstrated by having strong R&D investment and infrastructure, actively seeking new technologies for strengthening their businesses, and having an encouraging attitude towards new ideas. Illustrative datum of this point can be found in Table 2. Finally, the size and position of firms are interesting inputs from experts regarding the determinants of Blockchain implementation. While it is evident that Blockchain has been initiated from companies of various sizes and positions in the FSC, a number of experts expressed the notion that large organization with the power to mandate other entities are likely to be quicker in adopting and

diffusing Blockchain in their respective food supply chain. P12 gave an example "*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*."

According to the interviews, external influential factors to the implementation of Blockchain can come from regulatory bodies, consumers, and other organizations within the FSC. The influence from regulatory bodies often comes in two forms: encouraging the experiment of Blockchain and tightening rules. Five projects that were discussed by participants, were directly funded by the governments. Further, the majority of the participants predicted that scrutiny of food products will get stricter in the future, and referred to the same example of the FDA in the US. In one of their recent publications, the FDA expressed the demand for more rigorous food traceability activities and, recommended Blockchain as a potential solution (U.S. Food & Drug Administration, 2021). On the other hand, consumers are also seen to be demanding more traceability and transparency of food products, and willing to pay more for authentic and safety-proven products. P9 stressed on this point that "C*onsumer demand for trusts. With more and more food recalls becoming more and more frequent, the consumer demand is becoming significant*". Additionally, influential factors to Blockchain adoption in the food industry can come from other organizations in the industry. P7 shared their experience of carrying out a Blockchain pilot funded by the government, in which three companies volunteered to take part. They are competing in the same market, and two of them joined only after knowing that the first company participated in the pilot. Furthermore, in order for a Blockchain initiative to be fruitful, the collaboration and willingness to participate from organizations within the value chain are also crucial. P2 recalled, "*we are usually working with two or three connected companies in the supply chain at minimum, and sometimes even more, for an end-to-end solution*".

Lastly, the role of managers to the process of implementing Blockchain is highlighted by the participants. The attitude of top management is regarded as an important factor. Supportive and positive notions towards Blockchain technology from senior managers/ owners of the brand can serve as a great springboard for the projects to progress, as P8 explained "*there wasn't any negativity or concerns from top management. And I think that creates a healthy working environment*". Moreover, the involvement of top management during the projects is meaningful. P5 worked directly with the owner of the adopting organization from the start, and successfully deploy their Blockchain solution for the whole business. P9 and P13 are the CEOs of their companies that operates in the food industry. They both engaged actively with their Blockchain projects since the beginning and achieved fruitful results – large-scale implementation of Blockchain and successful pilot, respectively.

5. Discussion

Combining literature-driven conceptual model with empirical findings, an evidenced-based framework for adopting Blockchain in the food industry was developed, as illustrated in Figure 2.

At a broad level, the process of implementing Blockchain in the FSC is found to be similar to what extant literature has found regarding the adoption process of technology, with three sequential phases of pre-adoption, adoption decision, and post-adoption (Hameed et al., 2012; Martins et al., 2016). The activities at a more granular level are found to have differences, noticeably with the early introduction of the pilot, and the orientation of activities related to diffusing Blockchain for individual users. Furthermore, as extant literature has found a vast number of determinants to the implementation of new technology (for a comprehensive list see Hameed et al., 2012), findings from qualitative data helped to pinpoint the most relevant factors to the context of implementing Blockchain in FSC. For technology context- relative advantage, compatibility, and complexity are highlighted by experts, aligning with DOI theory (Rogers, 2003). Further, as the cost is found to have an impact on certain phases of adopting new technology such as RFID (Hossain et al., 2016), a similar notion is expressed by experts for Blockchain. For the organizational context- resources, readiness, innovativeness, and size and position are highlighted by the experts, consistent with what literature suggested as possible determinants for the assimilation of innovation (Pichlak, 2015). For

environmental context- the influence from regulatory bodies, consumers, and other organizations are also found in literature as pertinent factors to the implementation process (Hameed et al., 2012; Martins et al., 2016). Finally, top management attitude and involvement with the new technology, are found to be important for the Blockchain adoption process, consistent with what literature suggested (Damanpour and Schneider, 2009; Hameed et al., 2012).

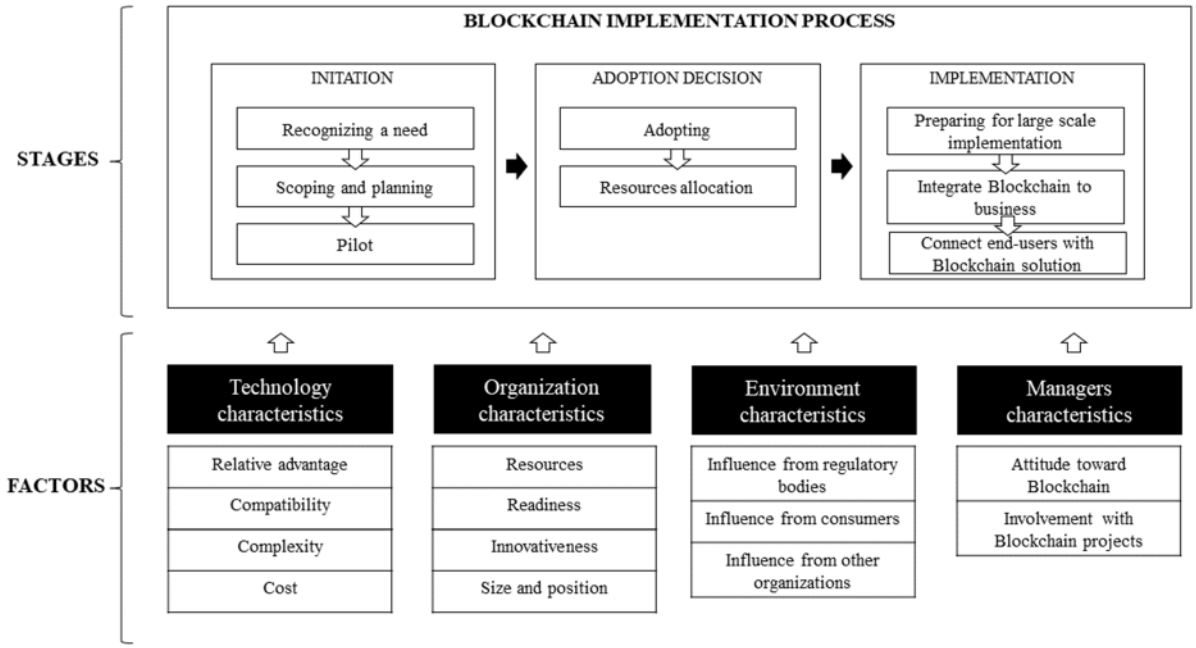

Figure 2. Evidence-based framework for implementing Blockchain in FSC.

6. Conclusion

With the rapid growth of Blockchain in the food industry, there is an evident need to also study the phenomenon and expand the knowledge of Blockchain in supply chain management (SCM) and FSCM. The aspect of implementing Blockchain is particularly important to examine, as a better understanding of the assimilation process can lead to successful adoption and generation of business value. However, since the current steam of research regarding Blockchain implementation in FSC is still in early development, this study proposed to elaborate upon existing theoretical perspective and conceptual models on Blockchain implementation, through the semi-structured interviews with industry experts, to arrive at an evident-based framework for Blockchain implementation in the food industry. The end result is a comprehensive framework with three main phases of adoption, eight typical courses of activities, four main categories of determinants, and 13 relevant influential factors to the process of implementation.

The contribution of this work thus is twofold. First, it expands the current body of knowledge about Blockchain for SCM and FSCM. Further, the framework of implementation proposed in this work can serve as the springboard for future studies to develop robust hypotheses and a research model for quantitative testing. Second, preliminary findings about the Blockchain implementation process in the food industry can serve as an effective reference and guidance for organizations in the food industry when considering Blockchain.

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Vu, Nam

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