DETERMINANTS OF BLOCKCHAIN ADOPTION AND PERCEIVED BENEFITS IN FOOD SUPPLY CHAINS

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Introduction

Concerns about food safety have grown over the past decade due to several food safety scandals such as the horse meat scandal in 2013 where foods advertised as containing beef were found to contain horse meat in retailers such as Tesco and Aldi. In response to growing food safety incidents, companies in the food supply chain are using certain technologies such as RFID. However, information that is taken from these technologies is not always trusted; thus, companies cannot achieve their full potential in terms of supply chain traceability and visibility (Tian, 2018). Decentralized and immutable storage of verified data can be accessed through the Blockchain technology.

According to Treiblmaier (2018, p.547) Blockchain can be defined "as a digital, decentralized and distributed ledger in which transactions are logged and added in chronological order with the goal of creating permanent and tamper-proof records". Blockchain can be used to ease paperwork processing, identify counterfeit products, facilitate origin of tracking and connect and manage IoT devices reliably (Hackius and Petersen, 2017). Despite the advantages Blockchain technology does come with a number of potential operational, organisational and technological challenges e.g. regarding security and latency (Wang et *al.*, 2019). Moreover Blockchain technology has not widely been adopted as it is not mature yet; for example in the food supply chain has started been explored by large companies such as Walmart and Nestle. Consequently, decision makers have to address the advantages and risks associated with Blockchain, as well as the implications of this growing technology for their specific organisation.

Although there are a few studies in the food supply chain area that have focused on Blockchain (Pearson et *al.*, 2019; Tian, 2018; Tse et *al.*, 2018), there is limited empirical work which captures the determinants of Blockchain adoption and explores the perceived benefits from its adoption. No study has conducted a holistic evaluation of the direct effects and the indirect effects of the determinants on Blockchain in the field of supply chain management. Thus, this study aims to explore the factors influencing supply chain, operational and logistics managers' decision in the food industry to adopt Blockchain and to develop a framework that is based on the technology-organization-environment (TOE) perspectives. The remaining sections of the paper are structured as follows: first the related theoretical framework and the methodology are presented. Then the results are presented and discussed. Finally, conclusions, limitations and directions of future research are provided.

Theoretical framework and Methodology

Several authors have explored the adoption of various technologies such as ERP and RFID by applying different theoretical models such as Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT) and the TOE framework. It is supported that the last two frameworks can explain better the technology adoption from the perspective of usage by firms

(Gangwar et *al.*, 2014). IDT is taking into account technological and organizational factors on firms' technology adoption decision, however it does not incorporate any environmental factors such as pressure from competitors. In this study TOE framework was adopted; it is proposed by Tornatzky and Fleischer (1990) to analyse the adoption of new IT technologies at an organisational level. TOE framework considers three main factors of an enterprise that influence the adoption of innovation: technological factors, organizational factors, and environmental factors. Technological factors entail the characteristics of the technology in this study Blockchain that influence its adoption e.g. perceived benefit, complexity, security (Gangwar et *al.*, 2014). Organisational factors include descriptive characteristics of a company e.g. firm size and managerial perspectives (Lian et *al.*, 2014). Environmental factors comprise external characteristics in company's environment such as firm size, trading partner support or pressure (Leung et *al.*, 2015). TOE framework is adopted as the foundation for exploring factors affecting the Blockchain adoption in food supply chain as it is more holistic and has robust empirical support in IS field more than other adoption frameworks e.g. IDT, TRA (Awa et *al.*, 2016).

The findings derived firstly from conducting a literature review; particularly a keyword search was conducted (i.e. "Blockchain" AND "supply chain" OR "logistics", "Blockchain" AND "technology adoption" AND "food industry") on major databases such as EBSCO, Google Scholar and Emerald Insight) and 26 articles were included in this review. Due to the limited knowledge about the Blockchain in the field of supply chain management, the second phase of this study utilised semi-structured interviews; a qualitative methodology is deemed more appropriate to ensure a holistic and in-depth understanding of factors affecting companies in the food supply chain in adopting and using Blockchain. Semi-structured interviews were conducted from May to June 2019 with supply chain managers (SCM) in the food industry in the UK who are responsible for the implementation decisions of Blockchain technology in the case companies (see table 1 below).

Code	Description of the company	Company size	Awareness of Blockchain technology
SCM1	Produces convenience food such as fresh sandwiches for a retailer and catering.	Number of employees: 11,300 Annual turnover: £1,498.5m	The company has good awareness of Blockchain and no implementation of Blockchain.
SCM2	Own-brand and branded ready meals manufacturer	Number of employees: 500 Annual turnover: £51.1m	Not much awareness and no implementation of Blockchain.
SCM3	Poultry meat producer	Number of employees: 10500 Annual turnover: £64.5 m	Some awareness of Blockchain and no implementation of Blockchain.

Table 1: Experts interviewed

Each interview lasted between 30 and 40 minutes. Interviewers were conducted through a variety of means i.e. telephone and online. An interview guide with open-ended questions was designed and interviews were recorded with the interviewees' permission and subsequently transcribed for data analysis. The following section provides the results of the literature review and the primary data organised by the key themes (i.e. technological factors, organisational factors and environmental factors and perceived benefits), followed by the presentation of a framework that takes both results into consideration.

Findings and discussion

The potential adoption determinants of Blockchain are discussed below around the three principle contexts - technological, organizational, and environmental. Moreover, the perceived benefits from Blockchain adoption and implementation are presented.

Technological factors

The main factors within the technological context that found are *relative advantage, perceived challenges and compatibility*. Relative advantage refers to the advantages that emerge from the adoption of specific technologies (Low et *al.*, 2011). In this context, Blockchain technology adoption in supply chain is associated with increased trust, seamless connectivity and reliability, business ethics, social responsibility, public safety and security (Wang et *al.*, 2018). Moreover, it is supported that Blockchain will play a crucial role in the implementation of other emerging technologies namely Internet of Things (IoT) (Hackius and Petersen, 2017; IBM, 2017).

However, new innovations come with several challenges that discourage companies from implementing those new systems (Arnold et *al.*, 2018). The main challenges around the emerging technology of Blockchain are scalability issues (e.g. Blockchain can only process nearly 7 transactions per second), privacy leakage (e.g. hacking), selfish mining e.g. temporarily control from group of miners of the network's mining hash-rate (Zheng et *al.*, 2017; Wang et al., 2018). Latency is another challenge as well as that if a mistake will happen in a transaction in supply chains it cannot be reversed (Wang et al., 2018). SCM1 argues that "No one has a well-established, working blockchain technology so this technology is not mature yet. Companies are not buying unproved systems that can have great impact e.g. on food safety". *"Like electric cars, if the infrastructure isn't there will have little application"* (SCM3). SCM3 further adds another challenge *"The quality of the blockchain system is only as good as the information used. If someone includes fraudulent information will that perpetuate the error? What if the identification of a container at the supplier is correct and someone replaces the content for something of less quality? How can I be sure that the physical product is the same identified by blockchain?". "Technology needs to ensure security against attacks/tampering… Some information might be confidential. How can we protect if the information is shared?"* (SCM2). Another point that was highlighted by SCM1 was the need for scalability and more flexible Blockchain systems as companies tend to have high number of product mix/finished products and/or ingredients. Blockchain has been currently applied successfully to single products such as egg production, coffee or Mousline purée by Nestlé and Carrefour (Nestlé, 2019).

Last but not least, compatibility can be defined as the degree to which the new technology fits with the potential adopter's existing values, work application systems (Low et *al.*, 2011). It is supported that if technology is considered incompatible, companies will likely to be unwilling to implement the innovation as it will not fit the existing processes (Arnold et *al.*, 2018). Thus, it is supported that is it important Blockchain to be integrated smoothly with the existing IT systems (Wang et *al.*, 2017). SCM3 supports that *"Can a company develop its own system and this system is unable to 'talk' with another company that is on another blockchain system? Does it need to become standardised? Who does this?".*

Organisational factors

Firm size, top management support, and existing technical skills are the factors that emerged under the organisational context. Firm size has been widely used to predict IT adoption in companies (Gutierrez et *al.*, 2015). A few studies support that large firms have the resources and can take easier the risk of innovation adoptions whereas small firms face constraints and challenges thus the avoid to adopt emerging technologies (Gibbs and Kraemer, 2004). However, other studies support that small companies can be more flexible due to their lower levels of bureaucracy (Gutierrez et *al.*, 2015). While large companies in several industries such as Maersk, Walmart are either already adopting Blockchain technology or are in the process of understanding how Blockchain can be used in their company small companies have a higher likelihood to adopt Blockchain technology than large companies (Schneider, 2019). The experts supported that SMEs companies within the food industry will not take the risk to adopt this emerging technology at the moment as do not have the resources. *"A small company would be reluctant to adopt a new system; SMEs would consider the additional cost of hardware/software/ training/equipment as a burden"* (SCM1). Blockchain implementation will be feasible in the next 3- 5 years (SCM3).

Top management support is also crucial for supporting any initiative of new technology adoption; top managers will provide the needed resources for the adoption of new technologies (Wang et *al.*, 2010). A study that has been conducted in Ireland found that top management support influences blockchain technology adoption in a positive way (NUI Galway, 2018). SCM1 supports that *"Within the company, the initiative to adopt Blockchain would come from senior management but the successful implementation depends on each department for example operation, technical and financial department"*. SCM2 highlighted that *"Initially, it will be difficult to change the culture"*.

Blockchain IT knowledge and skills within the company are considered as one of the Blockchain enablers (NUI Galway, 2018). This is also supported by SCM2 *"It will require a very different level of skills in the business"*. Well-trained and highly skilled employees are vital for a successful adoption of any technology (Wright, 2003). *"There is a need for a dedicated person, probably that is an IT expert but has an expertise within the food industry. Moreover, there will be a need to train the staff in using this technology* (SCM1).

Environmental factors

Within the environmental context, four factors emerged namely *competitive pressure, trading partner pressure, regulatory environment and customer pressure*. Regarding trading partner pressure, focal companies can use its size advantage to experiment with Blockchain and then transfer it to the suppliers, or focal companies may even require its suppliers to use certain type of technology in this case Blockchain (Premkumar and Roberts, 1999). For example, Walmart will require suppliers that provide fresh fruit and vegetables to use a digital ledger from September 2019 (Kharif, 2018). *"To ensure traceability and prevent food fraud, all pieces of supply chain need to buy into the BC, otherwise you have a big investment but you have a partial traceability. What is the advantage of some of the suppliers using BC and others not? It won't improve traceability unless the WHOLE supply chain joins…Some suppliers would not be interested on blockchain particularly the smaller ones (SCM3).*

Apart from the pressures from trading partners, competition and high rivalry increases the likelihood of adoption of technologies so as to remain competitive (Thong, 1999). According to Deloitte (2018), companies that do not take any action to think how Blockchain can impact them are at risk of lacking critical functions that this technology can offer and thus not be able to capture any growth opportunities offered by Blockchain. It has been supported that the regulatory environment can influence the adoption of technologies in a positive or negative way (Baker, 2011). Companies are sceptical about adopting Blockchain as there are different regulations across different countries such as USA, Belarus; thus, it is likely the incontinences between direct (i.e. officially introduced by the

government) and indirect regulations (i.e. general regulations imposed on tech companies) may hamper the adoption of Blockchain (Karatkevich, 2019; Mizrahi, 2018).

According to PwC (2018), Germany, Australia and the United Kingdom are facing the highest regulatory uncertainty. Codification of law and the development of a uniform global system for legal entity identification can act as enablers of Blockchain adoption (Ganne, 2018). Customer pressure is another important environmental factor that impacts new technology adoption (Al Rahbi, 2017). Consumers demand from companies to be able to trace the origin of products e.g. when consumers purchase fish they want to know that the company followed ethical and legal practices such as legal netting practices (Francisco and Swanson, 2018). *"If a client (retailer) demanded adoption of this technology, the company will do the necessary investment" (SCM1)*. More specifically SCM1 believes that the *"The main driver that might lead to adoption of Blockchain within the food industry is when it will be a client or a 3rd party audit requirement such as the BRC certification".*

Perceived benefits

For companies planning to implement, piloting or implementing Blockchain, many authors recognised the perceived benefits of its implementation in supply chains such as cost savings, minimisation of lead times, higher customer service, and increased flexibility (Korpela et *al.*, 2017). Queiroz et *al.* (2019) supported that through Blockchain supply chains are more transparent and though traceability more trust and security can be achieved. "It would prevent people from extending the 'best before date' with potential quality issues." (SCM1). In the food industry particularly, this technology will offer food traceability and the ability to fight counterfeiting (Hackius and Petersen, 2017; Queiroz et *al.*, 2019). Blockchain can decrease communication or transfer data errors and fraud, minimize inventory losses, stock outs, delays from paperwork (Thornpike, 2019). It help manage traceability from raw materials to end product, prevent errors with documentation and it will enable fast and effective recalls to build consumer trust (SCM1, SCM2 and SCM3).

Based on the findings, this paper develops a framework based on the TOE framework (Figure1).
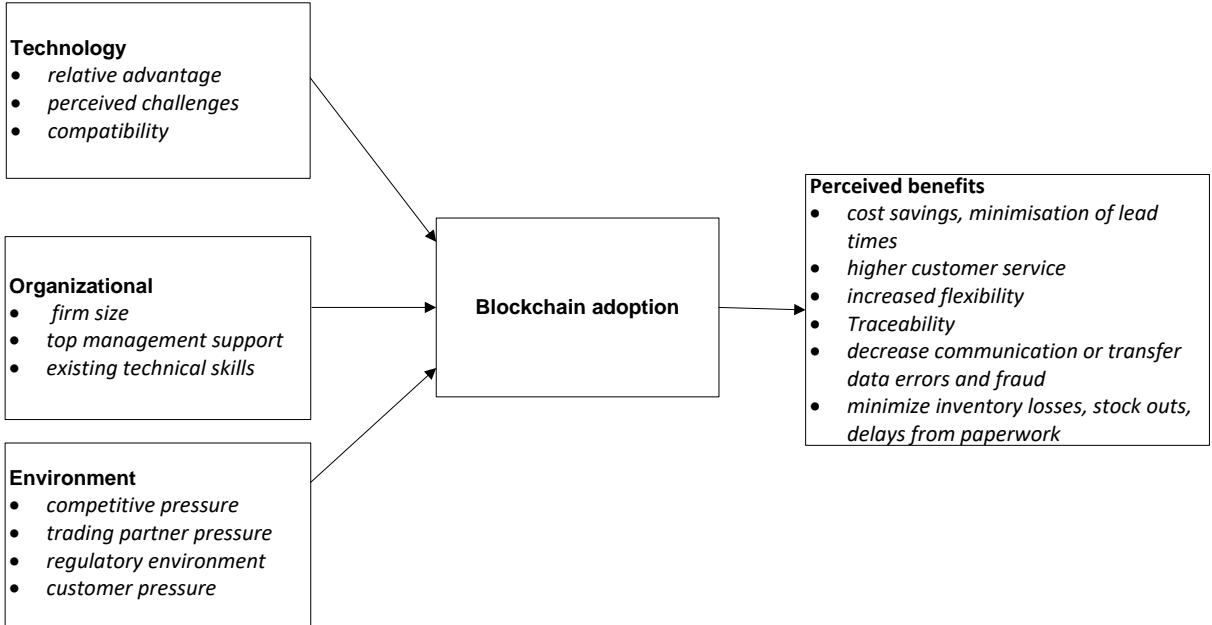

Figure 1: Blockchain adoption framework and its perceived benefits

Conclusions

This study aimed to determine the factors influencing supply chain managers' decisions to adopt Blockchain technology in the food supply chains, along with the potential benefits of its adoption. TOE adoption framework was adopted and adapted to identify the most important factors which were drawn from previous studies and primary data collected from companies in the food industry. Under the technological, organisational and environmental context the following factors were identified: relative advantage, perceived challenges, compatibility, firm size, top management support, existing technical skills, competitive pressure, trading partner pressure, regulatory environment and customer pressure. Regarding the benefits of the Blockchain implementation, these ranged from cost savings, minimisation of lead times, higher customer service, and increased flexibility, traceability and the ability to fight counterfeiting. Moreover, it has been found that currently it is very difficult to adopt Blockchain but in the future, when the technology is cheaper and less complex and proven to be more flexible it will become easier to adopt it. Despite this study's contributions, there are some limitations. The findings cannot be generalized to a wider population and the sample size within the food industry is small to provide a good representation of the population studied. Since Blockchain is also relevant for other industries such as logistics, future studies should consider respective companies. Our framework considers only three key areas within the boundaries of the TOE framework and these factors are the same for small and large companies, future research should differentiate the factors that determine Blockchain adoption in small and large companies and future studies should consider other factors.

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