An Investigation of the Implementation of Blockchain in the Food Supply Chain of Ireland

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Abstract:

Blockchain technologies were originally made popular through their application in Bitcoin. Blockchain is a distributed ledger with benefits including enhanced traceability and transparency leading to increased consumer confidence. Blockchain technologies have been integrated with other existing technologies to allow for free-flowing data throughout a supply chain. We have seen its use in financial transactions, logistical processes, and data management systems.

Blockchain has been integrated into food supply chain networks to provide the end consumer with a full farm to fork view of the processes and steps involved to get the product to them. This has opened a door for improvements on reliability, transparency, trust, and traceability throughout the food sector. Many studied have been conducted across many areas including Asia and North America, with few conducted on companies in Europe.

The Irish economy exports most of the food sectors produce. Much of this sector utilises traditional methods. The ability to provide a fully transparent environment for the food sector will provide the consumer with confidence the product they are getting is sustainably sources, farmed, processed, and sold. Research into potential applications of blockchain within Irish food sectors has not been visible. There is a lack of understanding as to the current implementation of this technology in Ireland.

This study uses a cross-sectional approach to determine the current position of Blockchain technologies across the Irish food sector. The limited knowledge of the industry to this new technology is highlighted but also discover the current implementation of blockchain within some companies in the Irish food sector.

Acknowledgment

Firstly, let me take this opportunity to thank all participants to the study complete in this paper. Without your time and opinions provided I would not have been able to complete this study and form a conclusion that will hopefully aid in future research.

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Chapter 1: Introduction

1.1 The food industry in Ireland

Continuous growth has been seen within the Irish food and drink industry over the past 10 years (Bia, 2019). This demonstrated the strength of this sector for the Irish economy. Ireland is the largest supplier of food and drink to the UK. Ireland's export market accounts for 80% of its dairy and beef production (FDI, 2020). This country is the largest net exporter of beef, lamb and dairy ingredients, as well as infant formula in Europe (FDI, 2020). In 2018, exports from this industry accounted for €12.1bn and is reported to have been to over 180 countries (FDI, 2020). This figure increased to €14.5bn in 2019 (Bia, 2019). 35% of these industries exports are to other European countries, which 34% goes to the UK markets and 31% of Irish exports are bound for other international markets (Bia, 2019).

The food sector in Ireland accounts for 7.7% of the gross national income (Bia, 2019). Exports from this sector accounts for 10% of total Irish exports (Bia, 2019). The food and drinks industry has a turnover of €27.5bn and a workforce of over 2000,000 employees (FDI, 2020). Within Ireland, this industry footprint expands the entire country, meaning the financial impact of this sector is shared throughout the populated and rural areas of the island (FDI, 2020). Out of the total manufacturing sector in Ireland, just over half of the expenditure is linked to the food and drinks industry. €11.1bn is estimated to be spend on materials, while €3.6bn is spent towards services, and a payroll bill of €2.1bn is also seen in this sector (FDI, 2020). 21% of industry turnover is accounted for by this sector with 23% of the total manufacturing sector expanding from the food and drinks industry (Bia, 2019).

With such a wide footprint across Ireland, continued growth, and development in the food industry in Ireland is essential to increase output, exports, and overall gross national income. Many technologies have shaken up all industries with developments improving performance, profitability, processes, and allowing prices to achieve a competitive advantage. (Asgari, et al., 2016) This has also affected the food and drinks sector throughout the world. Supply chains, operations, development, and retail have all been affected by new technologic advances (Avilés-Sacoto, et al., 2019).

Within a food manufacturing supply chain, the ability for a product to be in a sustainable, transparent, and traceable chain is now becoming a customer requirement (Rana & Sharma, 2019). Trust and safety, from a customer point of view, is now essential to build a successful sustainable food supply chain. Technologic advancement applications in this sector have been trialled in many counties in an attempt to further traceability, security and information flow (Zelbst, et al., 2019). The

use of Industry 4.0, RFID technologies, and Internet of Things have enhanced visibility, reactivity, trust, and transparency throughout a supply chain from source to shelf (Zelbst, et al., 2019). Companies such as Walmart have been able to successfully implement a technology known as blockchain by allowing this system to connect with other technologies (Kamath, 2018). This technology provided their supply chain with a competitive advantage over oppositions as it developed trust and transparency for their end users (Kamath, 2018).

1.2 Purpose of Study

Blockchain is a relatively recent technology which has been adopted from its original application in cryptocurrency and applies to other industries to replicate the benefits that it has to offer (Blossey, et al., 2019). The technology boasts traceability, transparency, and trust on all transactions, eliminating the need for third party intervention and bringing in smoother information flows throughout the members of that public or private network (Zhu & Kouhizadeh, 2019). With this technology being cloud based, it has the potential to be integrated with current server-based programs for ease of secure communications (Khan & Salah, 2018).

Many world-wide studies have shown the benefits of implementing Blockchain technology into a supply chain but not many studies have explored food supply chains outside America and Asia. This has left a gap in European study into this area. Yes, there are some elements of the companies studied which have ties to Europe, but there have be few studies conducted on a country's food supply chain application.

1.2.1 Aims and objective

This research project aims to discover if any Irish based food manufacturing or retail businesses are currently operating with any form of Blockchain integration in their current business processes or have future plans to implement and explore the potential applications of blockchain within their companies.

This study will attempt to answer one primary question:

"Are there blockchain implementations currently underway or complete within the Irish food industry?"

To aid in the development of an answer here, three sub-questions will also be reviewed:

1. Within the Irish food sector, do participants in supply chain know of the technology called Blockchain?
2. What are the expected factors which implement a successful operation supply chain, within the food industry?
3. What are the overlapping expected benefits between the operating of an efficient supply chain and an efficient computer system?

1.2.2 Research Project

This paper contains a study conducted upon the food sector in Ireland with particular focus to supply chain management area. Quantitative research analysis is used to implement and analyse a cross-sectional mono method research study in which the above research questions are answered.

This study will consist of a questionnaire distributed within the Irish food sector with particular focus to understanding the role of supply chain and potential role of blockchain currently in this sector. The study will also highlight the current role Blockchain is playing in food operations in Ireland.

1.3 Structure of this Research Project

This research project will consist of a detailed literature review of the current academic research in the area of Blockchain and its implementation or integration into food supply chains across the world. This study will also gather the advantages and disadvantages of using this technology and attempt to summarise the main learnings from other academics in this area.

A justification of the methodology chosen for this research paper will be presented along with the strategy and rationale for the methods used to conduct the research. The findings of the research will then be presented on a question by question basis in an attempt answer the main research question of this paper and the subsequent sub questions which also emerge.

Finally, the conclusion of this paper will include the limitations of the survey and potential avenues for future investigation into this area.

Chapter 2: Literature Review

2.1 Introduction

In 2008, Nakamoto developed a revolutionising technology that increased in popularity (Wang, et al., 2019). This technology is a shared digitally distributed ledger system made up of individual blocks of information all connected to form the technology knows as Blockchain (Wang, et al., 2019). This technology became widely known after its implementation in the popular cryptocurrency, Bitcoin (Yadav & Singh, 2019).

Due to this technologies inability to allow copying or editing easily, Blockchain is credited for providing a solution to the duplication of transactions seen in the financial industry (Kamilaris, et al., 2019). This means third party intervention is not required to complete a transaction and ensuring a payment can be made without the need for review or verification from an outside source (Kamilaris, et al., 2019). Each transaction is managed through the software's platform involving multiple computers that transmit, process, store and represent the data for ease of usability (Kamilaris, et al., 2019). Each data piece is known as a block or a node (Khan & Salah, 2018).

Each block is a piece of some form of information inputted onto the platform which connects to another piece forming a chain of interconnected blocks (Wang, et al., 2019). Each chain is accessible to all on the Blockchain system (Wang, et al., 2019). Each block is timestamped, dated and contains other unique identifiers which allow the block to find its place in the chain (Blossey, et al., 2019). No block can be destroyed, changed, or edited as a new block is created instead of a tampered or changed block of information (Yadav & Singh, 2019). This helps to create transparency and traceability of the inputs to the blockchain system (Yadav & Singh, 2019)

This technology has revolutionised the financial industry and has since been adopted into other traditional industries such as health care, and logistics (Queiroz, et al., 2020). Research into other potential areas of implementation have include handling and storing of records, tracking ownership of intellectual property rights and patent, real estate transfers, and electronic voting systems (Kamilaris, et al., 2019). Although this is a small list, it is not an exhaustive one.

There are many advantages that exist with the implementation of a Blockchain system. These may include data safety and decentralisation, accessibility, laws and policy adherence, documentation maintenance, data management, and quality control and enhancement (Yadav & Singh, 2019). However, there are also some disadvantages to this software including the time it takes to complete

a process, high installation costs, and high resource requirements all which require capital investment and coordination to achieve the desired result (Yadav & Singh, 2019).

Supply chain management is defined as “a set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer” (Mentzer, et al., 2001). Supply chain member collaboration and information sharing is essential to create an agile, trusted, dependable, transparent, and consumer responsive delivery system to achieve consistent high-quality products which are also cost effective (Kamal & Irani, 2014). The implementation of new technologies, development of new theories, and application of new business practices all result in greater innovative, secure, and customer focused supply chains (Asgari, et al., 2016) (Zelbst, et al., 2019).

Multi-partnered supply chains contain many moving parts, with multiple entities sharing and creating data due to the manufacture and distribution of products for customer consumption. Due to the number of links in a supply chain, some food chains have lost transparency in their network making it difficult to form consumer confidence in the produce being received. A new concept of “farm to fork” has been devised over the last number of years and is being implemented by many food companies to demonstrate the transparency of the supply chains (Kim & Laskowski, 2017). This has the added benefit to encourage deeper levels of trust for food production supply chains.

Supply chain management is also defined as the “integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders” (Lambert, et al., 2000). Integration of supply chains are expected to aid in achieving transparency here (Amin, et al., 2020). The ability to provide an integrated supply chain from source to shelf is seen as a challenge but one which advances in technology could aid (Lambert, et al., 2000). This would allow total visibility of information throughout a products supply chain, helping the source to understand customer needs and tailor towards them (Mentzer, et al., 2001). This would also benefit the reduction of waste, improvement of communication and overall increase in consumer confidence in that supply chain (Asgari, et al., 2016).

Over the last decade, many changes to the world of supply chain have resulted in the application of new technology which have driven disruptions and changes into this field (Zelbst, et al., 2019). Many developments from Industry 4.0 have progressed developments and improvements to result in new processes, theories, and practices to be implemented benefiting supply chain management (Queiroz, et al., 2020).

Supply chain integration is seen as a step to ensure security and increase the information flow through a marketplace allowing for increased consumer awareness of products available to them (Lambert, et al., 2000). Blockchain has the benefits which could aid in the integration of supply chains as the system developed does not allow for manipulation or destruction of data within a chain, therefore, providing full transparency at each point, creating a full, raw picture of each process along the way (Avilés-Sacoto, et al., 2019). This could applied to the production, distribution, transformation, and sale of a production through a supply chain (Rana & Sharma, 2019).

This paper aims to evaluate the current role blockchain plays in supply chain management practices today. It will also review the status of the food supply chain in Ireland and attempt to evaluate the extent of blockchain use in Irish food supply chains.

2.2 Supply Chain Management

Supply chains are seen as linear in nature but are complex and intricate when mapped out (Rana & Sharma, 2019). Consumer misconception of a straight-line process is not accounting for the number of direct and indirect steps taken to achieve a desired result for sale at the end of a chain. Supply chains are an interconnected web of entities along a service or products life cycle with a purpose to deliver a customer's requirement to the right place, at the right time, and for the right cost to allow the customer to purchase and consume the product or service (Lambert, et al., 2000). Managing this supply chain and the members contained is a real issue for individual players in any sector as it is a determining factor of the success or failure of that entity (Lambert, et al., 2000).

A food supply chains can be quite large in nature with multiple moving parts. Food supply chain management is therefore essential to ensure production and distribution of consumer products within the regulations, specifications, and requirements of each area (Tian, 2017). Supply chain management involves all members of a chain such as suppliers, manufacturers, distributors, retailers, and consumers (Asgari, et al., 2016). Products collect information as they travel through a supply chain (Amin, et al., 2020). The collection of this information can be shared throughout the supply chain, but accuracy is essential for the insurances of traceability (Yadav & Singh, 2019). With accurate information, high-quality product can be achieves resulting in potential cost savings through the identification of wasted processes from the review of movements (Yadav & Singh, 2019). Maintaining successful supply chains involves trust, sustainability, transparency, and traceability to be maintained throughout the full product chain, from farm to fork (Amin, et al., 2020).

Traditional supply chains contain many issues which affect the validity of the product for the user. The ability to process a product through a network without full visibility on each movement or activity leads to lack of accountability and traceability for that products ingredients and the firms attached to this product (Roy, et al., 2020). This creates issues of trust as the disconnected systems of individual firms possess different forms of information meaning a misunderstanding or mis handling of data is possible while a product moves from through a supply chain (Roy, et al., 2020). Absence of information sharing can lead to an absence of trust between organisations and customers as organisations are operating to a supply chain's triggers without full knowledge of the total information available in that chain (Roy, et al., 2020). This can result in increases in waste products, time lost, inefficiencies and other operational checks that may be complete later or earlier in the chain without knowledge (Lambert, et al., 2000).

Supply chain integration is a popular method to achieve full cooperation of all members within a supply chain (Kamal & Irani, 2014). This allows all information to be displayed to every member of a products chain to customer ensuring visibility of all steps (Kamal & Irani, 2014). Supply chain integrity contains many challenges for authenticity due to the ability to tamper, edit or delete pieces of information crucial for traceability (Amin, et al., 2020). This is mainly due to the use of traditional automated systems (Yadav & Singh, 2019).

2.3 Blockchain Technology

Blockchain is an infrastructure which works as a digital shared ledger to allow for direct and secure verified transactions among members in its software (Blossey, et al., 2019). Blockchain can be on a private or public server depending on the infrastructure and data ownership in place. Permission less public blockchains are accessible through internet connectivity and are accessible at any time or place (Blossey, et al., 2019). Permissioned private blockchains are only accessible through a predefined approval process allowing access to a registered network (Blossey, et al., 2019). Through these networks, security and monitorisation of processes complete can be maintained and validated as per the ownership agreements (Blossey, et al., 2019).

Blockchains use shared data infrastructure that provide real-time updates and processes using computer algorithms without third-party intervention (Abeyratne & Monfared, 2016). Each individual transaction, known as a block, is transmitted, processed, stored and represented in a way which is easily readable and accessible (Kamilaris, et al., 2019). Each block is time stamped and

linked to the previous block or node within its relevant chain. This allows a fully traceable path back to the original source (Kshetri, 2018).

Decentralisation, openness, security, and privacy are the four main characteristics of Blockchain (Tse, et al., 2017). Blockchain is linked to an individuals computer through cloud based infrastructure eliminating the need for hard ware investment (Tse, et al., 2017). This connectivity allows the technology to create copies of each block on the chain and store them on multiple devices across the connected chain to ensure the inability to edit, amend, delete or destroy any one piece of data. This is the technologies process towards decentralisation of data (Kamilaris, et al., 2019). This openness does require a three point security agreement or check before any piece of data can be added or stored on the chain to ensure authenticity and accuracy (Tse, et al., 2017). Although this may be potentially time consuming, according to other academics, this benefit can ensure security, and privacy of all data meaning the additional sign off measure is used as a wall before adding information to the chain (Tse, et al., 2017).

Blockchain has many advantages and disadvantages discussed by many academics. This technology is seen to provide quality improvements and cost reductions (Kamilaris, et al., 2019). Blockchain also provides benefits such as transparency, security, agility, trust, and traceability for its users (Yadav & Singh, 2019). The ability to increase consumer trust and digital transparency are important for supply chain operation (Amin, et al., 2020). This provides enhanced foods safety management throughout the food supply chain network allowing for monitored and assured security and traceability practices (Tian, 2017).

2.4 Supply Chain and Blockchain Integration

Strong supply chains contain elements of integration, full traceability of products, authenticity of data, and transparency of information (Asgari, et al., 2016). Currently, they are not seen as tamper-proof, due to the ability to edit, amend, or destroy elements of data streams created on traditional infrastructures causing trust implications for all members of the chain involved (Yadav & Singh, 2019). This is not the case with blockchain as its main premises is to eliminate the ability to edit, amend, or destroy blocks in the chain (Yadav & Singh, 2019). This is complete due to each transaction containing a trace of the previous transaction allowing for the user to know “where the block originated, when the data was inputted and how it’s being used” (Amin, et al., 2020).

Supply chain integration involves connectivity from farm to fork for all entities within a supply chain ensuring data sharing, collaboration, transparency, and traceability through the chain is available to

all (Fernando, et al., 2018). This eliminates the traditional thinking of a linear module supply chain and implements a multi-tiered cross collaborative supply chain where information passes backwards and forwards (Mentzer, et al., 2001). The ability to share and receive data from different areas of the supply chain not only improves the reactions of that chain but increases the operational efficiencies and reduces overall costs incurred within the supply chain (Rana & Sharma, 2019).

Blockchain supply chain management is expected benefit a number of areas across the many different sectors. 7 areas were identified by MahbubulHye, et al. 2020. These include transparency through accessibility and compliance of data, robust tracking of orders and assets, auditing of payments, identifying preliminary fraud, greater consumer trust, scalability of operations, and improved real-time forecasting (MahbubulHye, et al., 2020). Within logistic areas, blockchain has already been adopted as a primary strategy for control by some companies (Perboli, et al., 2018).

Blockchain can aid in a supply chains data management process providing security, validation and real-time data (Zhu & Kouhizadeh, 2019). This can be complete through the addition of RFID, bar codes, or other Industry 4.0 process models which can be linked or tracked throughout their movements through a supply chain (Zelbst, et al., 2019). This addition to a product can record and transmit data and the product moved through its lifecycle towards the consumer. This ensures traceability and transparency throughout a produces lifecycle while maintaining its security and integrity (Amin, et al., 2020).

Blockchains ability to provide a secure and decentralised operating environment for data management makes this technology ideal to implement in supply chain management as it aids in the development of a democratic chain instead of a dictator like chain (Roy, et al., 2020). This technology offers many potential possibilities to aid food supply chains manage products throughout their lifecycles ensuring credibility and accountability is management correctly.

Blockchains platform ability eliminates the potential for double transactions, which could be applied to order processing (Kamilaris, et al., 2019). Implementation of enhanced, non-invasive, non-destructive, and real-time communication trackers could aid in monitoring the quality of food produced while enabling the ability to track and trace the location of each product (Queiroz, et al., 2020). This could also aid in the elimination of inefficient movements within the products lifecycle as the data captured by this device is permanent, shareable, and can be analysed when it is stored on a blockchain (Roy, et al., 2020).

The ability to find and eliminate inefficiencies can also decrease costs eliminating waste of many kinds and improving the over chains as a whole (Ocicka & Razniewska, 2018). This would be seen as

a cost-effective use of the technology which could allow for potential of cost savings shared across a chain. Real-time data would provide for an effective, fast, reactive supply chain infrastructure which could lead to efficient and immediate processing of transactions throughout the chain (Kim & Laskowski, 2017).

As data is recorded immutably on this chain, this can provide an auditable record for inspection which could be set as a standard for the organisation or within that sector (Queiroz, et al., 2020). This set of data could include product details or contract details. The ability for the implementation of smart contracts in a blockchain would aid a supply chain in monitoring, adjusting, and tracking any agreements made with suppliers and consumers. Certain criteria for payment can be set and the payments can be sent after these deadlines are reached (Queiroz, et al., 2020).

2.4.1 Trust and Security

Within traditional supply chain systems, data can input, amended, and destroyed. It can also be manipulated so show a picture that may not be correct during audits or other reviews. This can cause major issues in the area of information trust. The ability not to fully trust the data supplied within a supply chain causes many detached and unconnected partners.

Security on the blockchain is maintained by the replicability of each piece of data entered on the blockchain (Amin, et al., 2020). As a blockchain is a connection of multiple computers across a software infrastructure, this allows the software to copy data to multiple locations across the software making each data note retrievable (Yadav & Singh, 2019). Blockchain security is a major issue throughout academia (Amin, et al., 2020). However, this security measure coupled with the inability to edit entered data allows for the system to demonstrate higher levels of consumer trust.

Smart contracts are a feature of blockchain technologies. These are a computer driven protocol aimed to facilitate enforce and verify all negotiations and monitor the performance of the contract (Roy, et al., 2020). These are also known as Proof of Agreements and indicate the standards, metrics, and contractual obligation compliance against the original contract to ensure standardisation (Roy, et al., 2020). Due to the trustworthiness of this type of contract, supply chains can use this to reduce operational risks (Roy, et al., 2020).

Within food supply chains, some elements of data manipulation do exist. This can be seen in the editing of expiration dates or incorrect storage of materials without sufficient testing facilities to ensure the products usability (Tian, 2017). A security factor blockchain offers to avoid such issues and manage the an effective traceable change is the immutability of its data stored (Galvez, et al.,

2018). This is seen as an effective food quality strategy and security measure leading to an increase in confidence and trust from the end user (Galvez, et al., 2018).

2.4.2 Transparency and Traceability

Product safety with the food sector is an essential factor which is maintained through effective traceability protocols (Kumar, et al., 2015). It is important for traceability to be maintained throughout a supply chain in order to complete product recalls if they appear (Kumar, et al., 2015). Effective traceability pinpoints the error in a system (Kumar, et al., 2015). This enables accountability to be held (Kumar, et al., 2015). If recalls do occur potential loss of future revenue and increased regulations in the food sector could be presented due to consumer perception and loss of trust (Kumar, et al., 2015). Implementation of effective traceability measures builds trust and customer relations throughout a supply chain, from members to consumers (Kumar, et al., 2015).

Improving the supply chain before regulations from governing bodies or loss of consumer trust has been seen can be overall cost effective as future changes and implementations after impacts of these changes are felt could be greater (Kumar, et al., 2015).

According to Kumar 2015, there are four main pillars of traceability:

1. Product Identification: details regarding weight, allergens, box type, specifications, best before dates, and production dates are all recorded and transferred with the product to allow for ease of identification.
2. Data to trace: relating to time orientation, storage conditions, checks, and other details required to complete product reviews.
3. Product routing: this related to the movement along the supply chain a particular product takes during its life cycle. Data such as storage location, duration, type, process, shelf life and order dispatched are all recorded within the supply chain.
4. Traceability tools available to the product: this includes RFID tags, bar codes, etc.

These above four pillars of traceability can be grouped with blockchain in order to achieve accurate and timely data collection (Kumar & Iyengar, 2017). Information collected is stored on the blockchain for that particular product and in real time is available to access through the system ensuring the ability to monitor traceability and display transparency on each movement of a particular material (Kumar, et al., 2015).

2.5 Current Implementation

Walmart developed a system using blockchain to enable the full traceability of product through its supply chain (Kamath, 2018). This was primarily due to the damaging affects tampering with product during a supply chain can have on consumer perception. In the 2000, a scandal involving the change in a material without knowledge of the customer resulted in widespread removal of this product and full investigation into the cause and attempt to fix the issue from happening again (Kamath, 2018).

Walmart were able to design a working platform which enabled real-time accurate data capture and transmission of a particular product to the user at a particular point in time. This proved a form of efficient data control (Kamath, 2018). Due to the saving potential, Walmart developed this technology with their Chinese Pork chain to demonstrate the effectiveness of this process. Their pilot demonstration with their Pork supply chain highlighted the ability for blockchain technology to enhance the ability for transparency, accuracy, and trust at each stage of a products life cycle (Kamath, 2018). In relation to Pork, the information regarding the animal's condition at the farm through to the storage and transportation of product right up to selling point, enhancing the ability consumer confidence measure and demonstrating the farm to fork concept (Kamath, 2018).

Walmart demonstrated a saving for all within a supply chain. Their blockchain solution leverages current technologies and enhanced the possibilities of the food chain at that particular point in time (Kamath, 2018). They created a process which allowed the ability for businesses to solve problems such as "time efficiencies, cost reduction, long-term good will, and revenue generation" (Kamath, 2018). They proved the need for collaborations and communication on all ends to ensure this technologies success and its operation at the best of its ability (Kamath, 2018).

2.6 Issues and Concerns

There are still many issues that exist for using Blockchain. If comparing to traditional server-based systems, blockchain is lacking in performance due to its data protection triple copy system for each entry made. This also increasing the level of available resource required to operate the Blockchain and affects processing speed and increases storage costs. With the increased processing time, there could be knock-on effects such as loss of efficiency or productivity when integrated with traditional based systems.

The ability to develop trust across members of a supply chain ensuring collaboration and integration is seen as a potential pitfall due to the individual and differing objectives of the individual

organisations within a chain (Roy, et al., 2020). This includes raw material suppliers, manufacturers, warehousing and logistics areas, and retail (Roy, et al., 2020).

Within supply chains today, the ability to trust data is important to ensure the end user's confidence level is high. Currently counterfeit products to pharmaceutical goods are available to consumers increasing trust issues (Roy, et al., 2020). Resource sustainability and efficiencies are also concerning as they pose increased operational costs, disruption to the distribution of goods, and processing delays or ineffective production processes (Roy, et al., 2020). All these can cause a lack of confidence towards a food supply chain due to delays, unsustainable practices and other inefficiencies which may affect the consumers perception.

Governmental and private sector barriers are affecting the potential for the implementation for blockchain supply chain integration due to the regulations and restrictions in place (Kamilaris, et al., 2019). Organisations operating in the private sector are reluctant to share full information within a supply chain of a product as knowledge is seen as a potential for competitive advantage. This is an issue when reviewing members of a supply chain and their organisations objectives as there are usually gaps or misaligned goals due to the incomplete sharing of information (Kamal & Irani, 2014).

Chapter 3: Research Question

3.1 Introduction

Blockchain supply chain integration is common across many sectors worldwide. It is clear companies such as Walmart have explored the technologies usability and have implemented successfully integrated supply chain improvements using Blockchain (Kamath, 2018). Although there many examples, academia has focused on examples from America and Asia as driving forces for what can be achieved. Within Europe, there are limited research papers containing data on supply chain and blockchain integration.

Food supply chains are some of the most sensitive sectors due to their end consumption destination. This sector has seen numerous scandals which have eliminated consumer trust and exploited the

lack of transparency and accountability for some enterprises operating in this area (Kamath, 2018). Recently supply chain integrations, sustainability movements and full transparency methods have all aided in the increase of consumer trust (Nakandala, et al., 2017). However, this growth has also left some doubt as data sources and security protocols appear to be missing. Technologic advances such as RFID, IoT, Industry 4.0 and Blockchain, security and data protection leading to accountability and traceability are more prevalent (Zelbst, et al., 2019).

3.2 Research Question

This paper aims to explore and evaluate if blockchain technologies have been implemented in the food industry of Ireland, with particular focus to supply chain management functions.

This information will allow an insight into the adoption of blockchain into countries outside North America and Asia and understand the knowledge of supply chain practitioners across the Irish food market of emerging trends.

The primary question of exploration is:

"Are there blockchain implementations currently underway or complete within the Irish food industry?"

Particular focus will be granted to the area of supply chain management as this area spans a full product chain from farm to fork. In order to evaluate if blockchain has been implemented in the food supply chains across Ireland, three subset questions will also be considered:

1. Within the Irish food sector, do participants in supply chain know of the technology called Blockchain?
2. What are the expected factors which implement a successful operation supply chain, within the food industry?
3. What are the overlapping expected benefits between the operating of an efficient supply chain and an efficient computer system?

Chapter 4: Methodology

4.1 Introduction

This chapter discusses the methodology approach used for this research project. The research framework, research approach and strategy, data collection approach and other strategies implemented are discussed. The chapter will also discuss the research tool selected, validity and reliability of the research, and ethical considerations and limitations that are present.

This research aims to collect and analyse the current position of Blockchain implementation across food industry subsectors to understand the future implementations and potential implementations for this technology over the next 5 years. This research will gather knowledge on if there are Irish food companies currently exploring the implementation of this technology. It will also analyse the participants opinion of critical factors associated with a successful supply chain and a successful technological system in the aim to overlap uses for blockchain technology within this industry.

The difference between quantitative and qualitative research approaches has been used as a starting point for many research project when attempting to narrow down the tools and techniques which apply to a particular study being undertaken (Bryman & Bell, 2011). The distinction between these two approaches can have an effect on the direction of a research strategy. Quantitative approaches involve the "quantification in the collection and analysis of data" (Bryman & Bell, 2011). This focuses on the quantity of data collected and the ability to analyse this information into numerical data inputs (Bryman & Bell, 2011). Quantitative methods enable the link between the past research and current theories to allow conclusions to be drawn in relation to their interaction (Bryman & Bell, 2011). Qualitative approaches review and emphasise the words used is a study (Bryman & Bell, 2011). This relationship can be analysed to identify patterns and explore answers against the pattern of suggested theory (Bryman & Bell, 2011). However, research methodologies are not strictly either quantitative or qualitative. It is possible to use a mixed method involving both quantitative and qualitative methods of research.

This research will involve the primary use of quantitative methods for the development of quantifiable, statistical results and process this into usable information. This will develop understanding of the data collected with the aim to add to potential future research avenues with this area of research.

To determine the potential structure for the completion of the research, the tool framework knows as the research onion was implemented to display the method of data collection taken for this study.

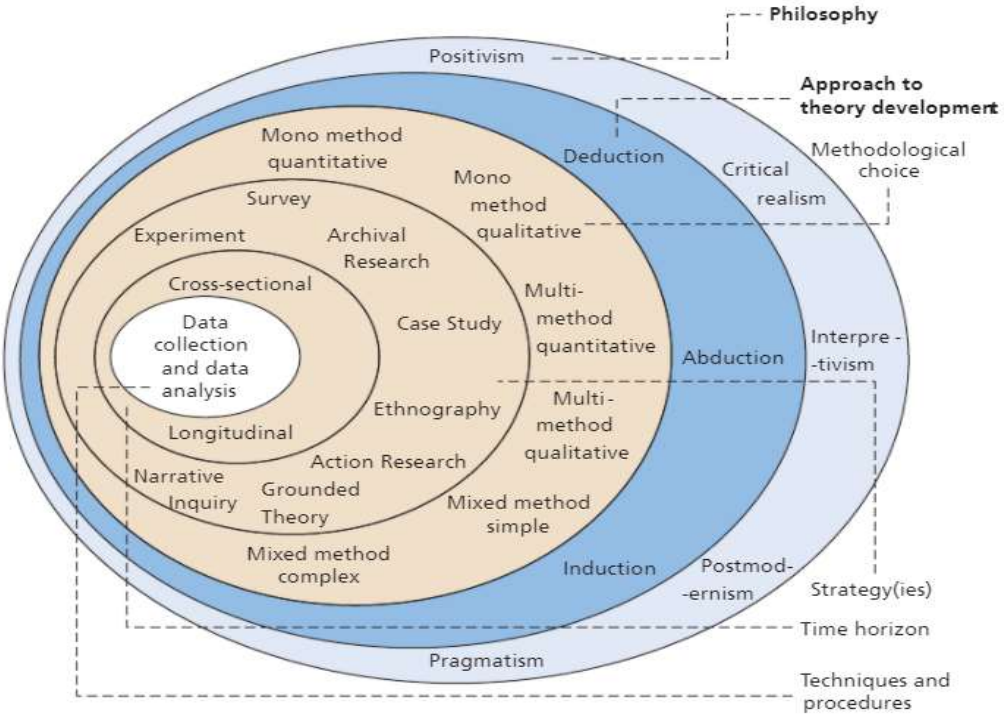

Figure 1: The Research Onion

4.2 Research Philosophy and Framework

"A system of beliefs and assumptions about the development of knowledge" is the basis of research philosophies (Saunders, et al., 2019). Assumptions are made throughout research and fall into three main categories. Ontological assumptions relate to the nature of reality and displays the researchers view of the environment (Saunders, et al., 2019). Epistemological assumptions refer to the knowledge itself and what is seen as acceptable, legitimate, and valid (Saunders, et al., 2019). Finally, axiological assumptions relate to values and ethics (Saunders, et al., 2019). Each of these assumption methods pose their own research types. This research will use a positivism style position in order to achieve the desired results. The research will focus on external, independent research gathering of multiple operational facilities, using in depth analysis of the results gathered (Saunders, et al., 2019). Through the creation of the chosen research tool, distance from the respondent can be seen to provide a value free, measurable and quantifiable range of results without the influence of the researcher (Saunders, et al., 2019). Positivism approaches focus on fact rather than value

(Bryman & Bell, 2011). This allows an accurate, scientifically analysed set of results to be formed and evaluated (Bryman & Bell, 2011).

The researcher chose to pursue a deductive reasoning approach to their work. This means the "conclusion is derived logically from a set of theory-derived premises" (Saunders, et al., 2019). It is a form of quantitative data collection meaning the method used is structured, designed to aid analysis, and generalised (Saunders, et al., 2019). In the event of limited time for a substantial selection of individual interviews, the research tool chosen is a survey. Surveys are a time saving and easily distributed questionnaire which can reach more people in a limited timeframe without the inclusion of researcher bias but contain an increase of non-responses (Bryman & Bell, 2011).

4.3 Research Methodology and Design

Research design related to the framework chosen for collection and analysis of data (Bryman & Bell, 2011). The research methodology is the tool used to complete the collection of data (Bryman & Bell, 2011). There are many typed of data collection methods, from interviews and surveys to case studies and extensive literature reviews (Bryman & Bell, 2011). This research employs a cross-sectional research design. Cross-sectional designs are used to collect data from multiple cases at a single point in time to generate reviewable results which contain two or more variables (Bryman & Bell, 2011). This style of research can be used for either quantitative or qualitative methods (Bryman & Bell, 2011). As this research aims to understand opinions from multiple organisations, variation is received from the answers collected, expanding the view across the sector in question. Cross-sectional designs include questionnaires and structured interviews (Bryman & Bell, 2011).

The researcher chose to use a questionnaire design to aid in the collection of information from multiple companies across the island of Ireland during a four-week period to aid in the formation of a conclusion relating to the research question.

The researcher chose this type of research method due to the advantages received. The advantages of questionnaire use include cost effectiveness, speed, avoidance of interviewer bias, and convenience for respondents (Bryman & Bell, 2011). Although there are numerous advantages, some disadvantages do exist and are seen as limitations for this research study. Disadvantages such as the inability to probe further on answers, difficulties in ask open ended questions, ability to know all the questions before answering to give time to prepare answers, inability to ask a large number of questions, inability to determine who is answering the questionnaire, and potential for low response rates (Bryman & Bell, 2011).

4.3.1 Questionnaire Design

A questionnaire is chosen as the preferred method for this research. To gather a broader understanding of the opinions of more companies within the food industry, this method of analysis was deemed the most effective for completion and distribution within the timeframe provided and the current environment of today.

The food industry's size crosses many subsectors which provides a high level of difficulty to achieve multiple interviews or investigations. This would have involved a high availability of time and resources, of which were limited during the completion of this research. A questionnaire was seen as the most time effective method for research for this study.

An online survey tool named SurveyMonkey.com is used to design the research questionnaire. This tool allows users to choose from multiple layouts, features, and suggestions, in order to create the desired view. The number of questions is limited to 10. This limit removed the potential for further developing answers and left the survey looking at a surface view of company perspectives across the food sector. Although this limit is present, a feature of the tool is that each question can be marked as required, increasing the potential of the survey being 100% completed and sent back.

Questions are designed to be short, and to the point. The likert scale is implemented in 25% of the questions. Multiple choice answers are possible in 50% of the questions created. The final 25% of the questions were aimed to understand the participants position in the company and to understand the sector the company operates within. These contain a selection of answers to choose from.

The SurveyMonkey.com tool also allows users to email, share on social media, and copy a unique link to send to potential participants in order to collect responses. The researcher uses this multi-platform shareability to increase the number of potential respondents to this questionnaire. However, with multi-platform potential, the ability to reduce unwanted sector feedback is present. This meant the reliance on snowball and convenience sampling methods.

4.3.2 Sampling and Population

The food industry in Ireland is varied across many subsectors. From farming to manufacturing to retail, food industries contain a wide variety of technologies, structures, procedures, and processes which result in many different areas of exploration. The researcher uses a non-probability sampling process to distribute the questionnaire to a targeted audience due to the complex and intricate nature of supply chains. The area chosen for particular focus includes, but is not limited to, the upstream side of a supply chain, sourcing, manufacturing, and logistics of raw materials or part processed finished goods which required further movements through a supply chain before they are consumed.

To achieve a sample of companies operating within the food industry, a convenience sample of registered members of websites such as Bord Bia and Food and Drinks Industry were collected. General email addresses were received for each company on this list, which consisted of 40 companies across different subsectors of the food industry. This included dairy and meet processing, confectionary goods, frozen and fresh supply goods, pre-prepared meals, and other food subsectors. Through this sample of the food industry, a response rate of 20% was achieved. Non-responses were most common. However, 25% of responses indicated the action as outside company policy or were not received due to end user security settings. (Bryman & Bell, 2011)

Snowball sampling methods are also employed to distribute this survey (Bryman & Bell, 2011). The researcher contacted a group of 5 individuals working within the parameters of the first round of issued surveys. These individuals are not working in any of the locations previously emailed, ensuring a variety of answers. A contact list of 5 individuals was created and each individual was encouraged to share the survey with other members of food supply chain operations across other companies but within the parameters of a sourced, manufactured or part processed good. Social media, by way of LinkedIn, was utilised to distribute this survey also.

As this questionnaire allowed for participants to remain anonymous, knowing where to send a reminder is difficult. The researcher therefore chose to send a reminder to all participants after two weeks.

Over a timeframe of 1 month, which consisted of both convenience and snowball sampling methods with a reminder to participants, a total of 18 responses were received through multiple platforms, email, social media, and messenger apps. The overall response rate to this survey totalled 40% of the known number of individual participants who received the initial questionnaire. Although the

recommended retrieval rate for questionnaires is circa 50%, this score is good when consideration is given to the volume of security blocks and company policy replies received.

4.4 Data Collection Method and analysis

The food industry of Ireland is quite large, with many companies spanning multiple subsectors of this industry. In order to contact the required target market spanning this industry, the researcher used email, and platform sharing of this surveys link in order to develop responses. An email list of 35 potential participants was created using Bord Bia members across Dairy, meat and livestock, fish and other agri-food sectors. The food and drinks institute was also used to find contactable companies also across different industries; for example, confectionary, prepared foods, and retail.

Upon completion of the questionnaires, each submitted questionnaire was extracted from surveymonkey.com and imported into an excel spreadsheet for analysis. The data was compiled into numerical tables for ease of identification of patterns and understanding of the information provided. The research is displayed in graphical formats including but not limited to pie charts and bar charts. The analysis of some data patterns does expand further on the information gathered to allow for the researcher to discuss deduce from the results the details this information is providing.

The analysis of this data is aimed to provide an understanding of the current opinions across the Irish food sector with relation to blockchain technologies. Each question will provide some evidence into this opinion and expand on the current knowledge of the industry and its relationship with blockchain.

4.5 Validity and Reliability and Bias

Reliability of research within quantitative methods is essential to ensuring the accuracy and replicability of the information received (Bryman & Bell, 2011). This research is conducted during a specific point of time. The participants of the research all elected to contribute their opinions which may change over a period of time. The replicability of this research tool conducted is possible as the researcher details the questionnaire administered, and collection of the population sample. This allow presents the framework of design and is easily replicable with the same tool. However, the replication of the results received may vary depending on the participants knowledge and environmental potential at a point in time. Participants were asked their opinion on topics which they may or may not have heard of before completion of the questionnaire, these participants

viewpoints may change if administered with the same questionnaire in the future resulting in a variation of results.

The validity of the study is measured on two grounds, the relationship of the results to the question being answered, and the ability to use these results as a general consensus for the wider industry (Bryman & Bell, 2011). Within this study the questions asked can be split into 3 subsections, each aimed to gather information relation to the composition of the final conclusion. The selection of the population sample generated proposed a wide contribution from multiple subsectors of the Irish food industry. Although the results received were focused primarily to manufacturing or processing phases of a supply chain, it can be assumed that this does not give a full picture of an entire supply chain. However, what is does deliver is a valid opinion from this area of a supply chain.

Within the research, elements of bias results do exist. With the high level of non-responses to the surveys distributed, the results are potentially not reflective of this are not fully reflective of the views of different companies within this sector. This means, the results achieved my not be replicable in another study as the timeframe, group used, opinions gathered, and environment of the study may be different than current conditions.

4.6 Ethical Consideration

Ethical consideration was taken across all areas of this research. Within the sampling process, the companies discovered on the above websites were all used regardless of the industry they are operating in. this reduced the level of researcher bias on the selection process. Privacy of participation was upheld with the use of a questionnaire which ensured each respondent remained anonymous. Data collected does not contain any identifying factors for a company or individual. Individuals are asked to provide their current level within their organisation and the industry subsector their company primarily operates. All information collected is stored on the encrypted USB with password protection for all files containing results, analysis, or any such sensitive data.

The collection of email addresses from websites has been compiled into an excel spread sheet containing a password for entry. This sheet is stored on an encrypted USB key. All emails were sent using BCC format for each company ensuring data protection in the event of an error email address. This information is being stored for the required timeframe and will be correctly destroyed.

4.7 Limitations of this Research

There are many limitations within this research. The author highlights the response rate from the distribution of the questionnaire. This representation of the surveyed sector is small and may not accurately display a view of the current knowledge within the food sector surrounding this area of inquiry. This sample size has the potential to not reflect the wider industry as it is only a selection of some sub-sectors within the food industry.

The use of the survey creation tool, surveymonkey.com, resulted in the limited number of available questions. A limit of 10 questions could be created meaning framing each question was required in a particular way to ensure clarity and understanding, which achieving an accurate answer without any misunderstanding to the question being asked. This tool created and edits grammatically correct sentences to the US English version and not to the Ireland English version. Some corrections were made after the initial creation of the survey as a result of this.

Across the analysis here, many sub-sectors did not take part in this questionnaire meaning their opinion was not captured. Although this study has taken into consideration a sample of the food supply chain in Ireland, it cannot fully assume that the results do speak for the wider sector.

4.8 Conclusion

In order to evaluate the main research question of "Are there blockchain implementations currently underway or complete within the Irish food industry?", a study was conducted within the Irish food industry in the area of blockchain knowledge. The use of quantitative techniques resulted in the use of a deductive cross-sectional research tool known as a questionnaire. Questionnaires have advantages and disadvantages depending on how and why they are used. For this research, a questionnaire was implemented in order to contact and extract the opinion of multiple participants across the Irish food sector, within the limited time available.

Similar to an onion, research take on a layered approach. When research is viewed as with qualitative or quantitative, further review is required to find the direction a study is taking within that area. This study will undertake a positivism philosophy with a deductive approach to its theory development. As the strategy involved will consist of a questionnaire, it is assumed a mono method quantitative framework is being implemented. The total size of the sector involved would require vast availability of time. In the absence of this, cross-sectional analysis was chosen to collect data quickly and efficiently.

The study was conducted using the described questionnaire. This questionnaire was created through the online tool, surveymonkey.com. The unique ability of this tool allowed the researcher to distribute their questionnaire to multiple participants across Ireland using email, messaging services, and social media. Consisting of 10 questions, this questionnaire was estimated to take 5 minutes to complete. This short timeframe was maintained to encourage participation in the study.

The information gathered was analysed through Microsoft Excel which allowed graphical and statistical analysis of the information in order to identify any patterns or potential errors in the data received. This data analysis allowed the researcher to develop the findings and discuss potential future areas of study, which are discussed in the next chapter.

Chapter 5: Findings and Discussion

5.1 Introduction

In this chapter, the analysis of the data collection process will be discussed in detail. This will include a discussion on the findings from the analysis process itself. The use of graphical tools such as pie charts and bar charts will aid in displaying any relevant findings. These graphical charts have been chosen as they are easy to read and allow for a quick understanding of the results before reading the analysis provided.

This study aims to answer if blockchain has been implemented into companies within the food industry across Ireland. To aid with understanding this primary questions, three sub-questions have to be answered. These include:

1. Within the Irish food sector, do participants in supply chain know of the technology called Blockchain?
2. What are the expected factors which implement a successful operation supply chain, within the food industry?
3. What are the overlapping expected benefits between the operating of an efficient supply chain and an efficient computer system?

5.2 Research Analysis

5.2.1 Question 1: Companies Main Operating Environment

The first question is aimed to determine the current operating market of the company participating in this survey. Out of 18 respondents, the questionnaire received responses from 5 manufacturing facilities, and 5 retail stores spanning general retail, fast food and restaurant supply networks. 4 participants were from prepared food suppliers while 2 participants classified their company as raw material suppliers. The remaining 2 participants have been classified as other. This classification is due to their generalised identification of their operations as their indicated operating environment included research, and sales, supply, and logistics.

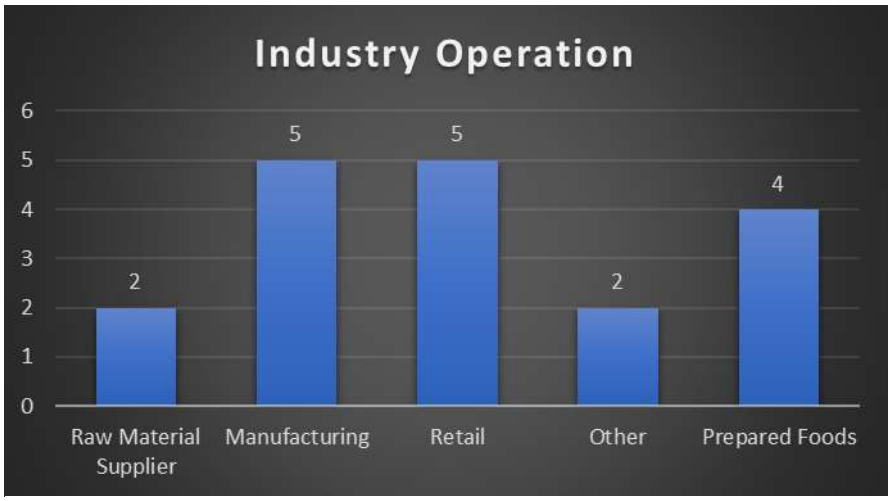

Figure 2: The Industry Breakdown

In order to review the results accurately, the decision to group respondents' answers into similarity categories was made. Answers relating to manufacturing are all grouped as manufacturing. A group indicated raw materials as their primary operating group. They were grouped as such. For prepared foods, two participants indicated this area of manufacturing directly. Another participant has been grouped with this title due to the nature of their indicated operations. Multiple others indicated streams resulting in a categorisation of retail. This provided a structured view of the industrial organisations participating in this study ensuring ease of analysis.

This survey was distributed within areas including dairy, meat and fish processing, prepared foods, material suppliers, confectionary manufacturing organisations and other sourcing and retail operations across the food industry.

5.2.2 Question 2: Job level of participant

This question aimed to understand the participants job level within their organisation. 33% of the questionnaire has been answered by middle management, 22% from either employee level and owner, c-level, executive, 17% are in senior management, and 6% are in consultancy. This level of distribution indicated a wide range of opinions have been obtained across all levels within organisation of the food sector.

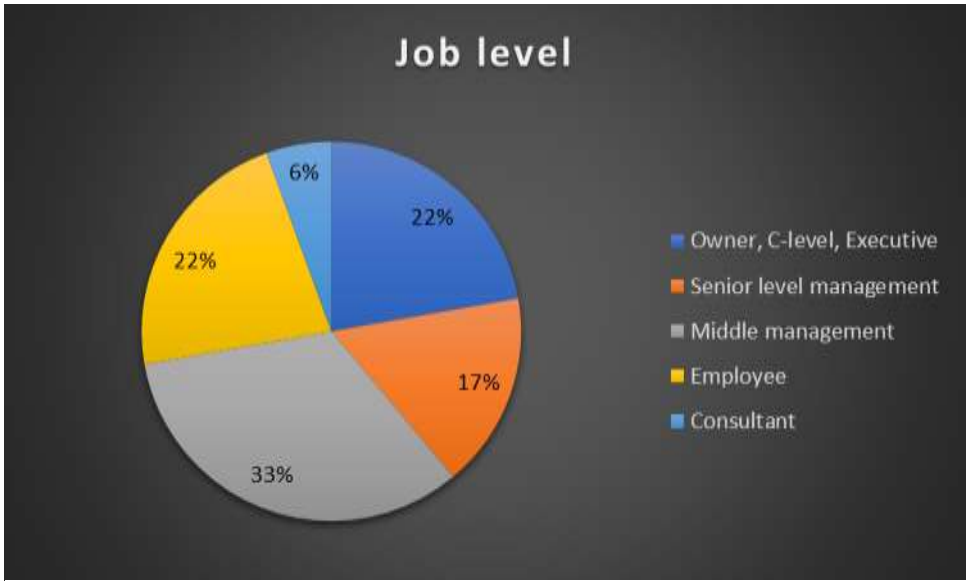

Figure 3: Job Level

5.2.3 Question 3: Supply chains in the food industry are trusted, accessible and transparent

This question was designed to achieve the opinion of the participants on the statement made. Participants were asked to indicate their response. The responses received indicated that 28% strongly agree with this statement, and 28% neither agree nor disagree. The majority of respondents agreed with this statement with a total of 44% indicating this option.

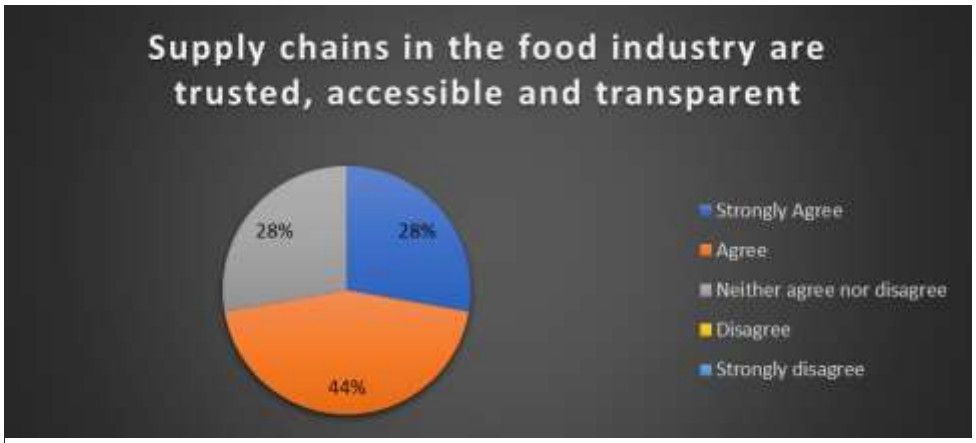

Figure 4: Trusted, Accessible, and Transparent

This suggests that currently supply chains operating in the food industry in Ireland are trusted, transparent and accessible. However, there are 28% of respondents who do not have an opinion on the above statement meaning there may be a different view that is likely to need further investigation and more in-depth questioning.

5.2.4 Question 4: Supply chains in the food industry are secure, and information is tamper-proof.

Unlike question 3, the results received for question 4 display a mixed view in relation to the ability for supply chains operating in the food industry in Ireland to be secure and have their information tamper-proof. 44% of respondents disagreed with this statement and 6% strongly disagreed. 22% agreed with the statement with 11% strongly agreeing. 17% of respondents failed to register an agreement nor disagreement with the statement.

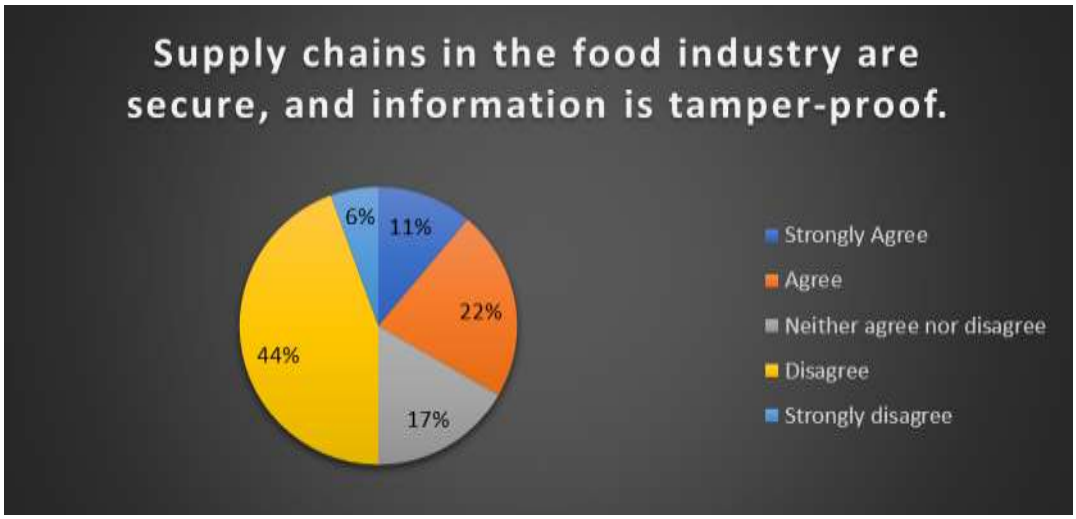

Figure 5: Secure and Tamper-proof

Upon further investigation, out of those who disagreed with the statement, 38% were middle management, 25% employee level, 12%-13% either owner, c-level, executive, or consultants, or in senior management.

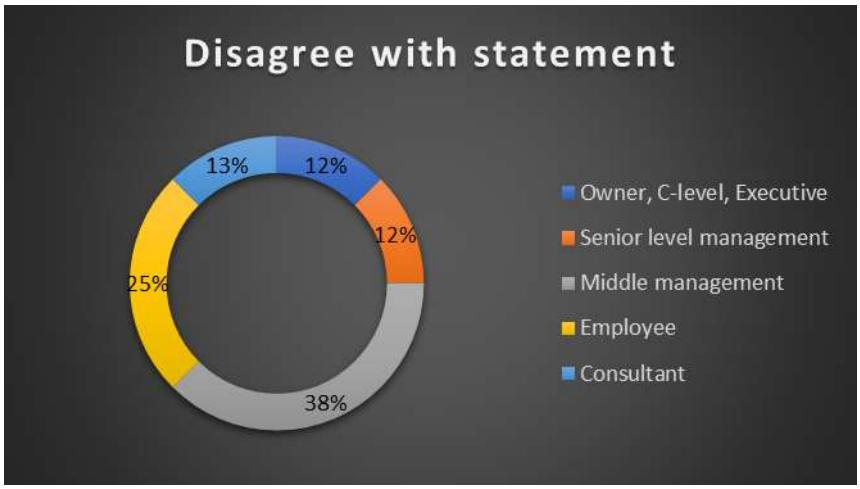

Figure 6: Job level of disagreeing participants

As this opinion is from multiple employment levels across a business. The below graph indicated these participants also are spread across different operating areas indicating a pattern of distrust. Manufacturing, retail, and prepared foods have the higher number of respondents which have indicated disagreement with this statement.

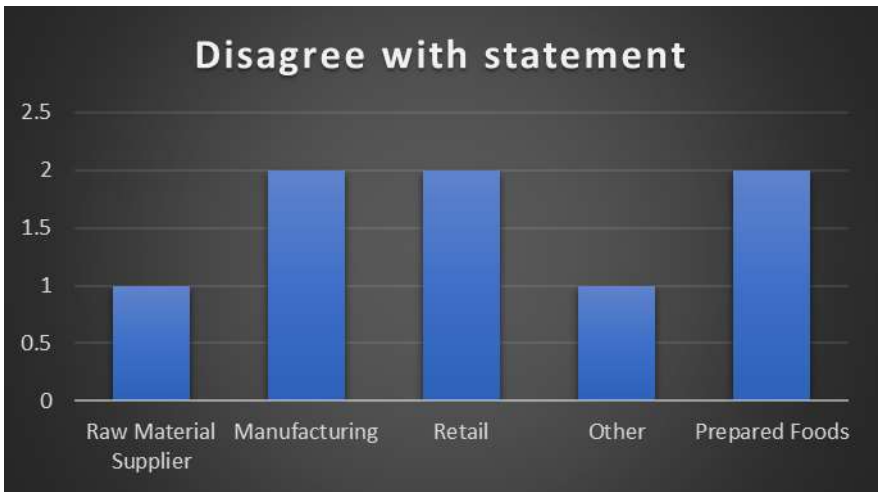

Figure 7: Industry operations of disagreeing participants

Over half of all respondents indicated a disagreement to the security of a supply chain. This is concerning as the food industry distributes essential goods which require accuracy of storage, transportation and information to achieve trust from its end user. Although most people indicated there is a level of trust, transparency and accessibility across supply chains, the results of this question indicate the security and tamper resistance of information is not trusted.

5.2.5 Question 5: The essential factors critical for a successful supply chain operation

After question 4, the intention for question 5 is to allow the participants to indicate their critical factors for a successful supply chain. Some common themes were provided with the options for participants to add their own. This selection indicated the level of importance particular factors are having on a food sectors supply chain meaning the need for this supply chain to match the requirements expected from its customers.

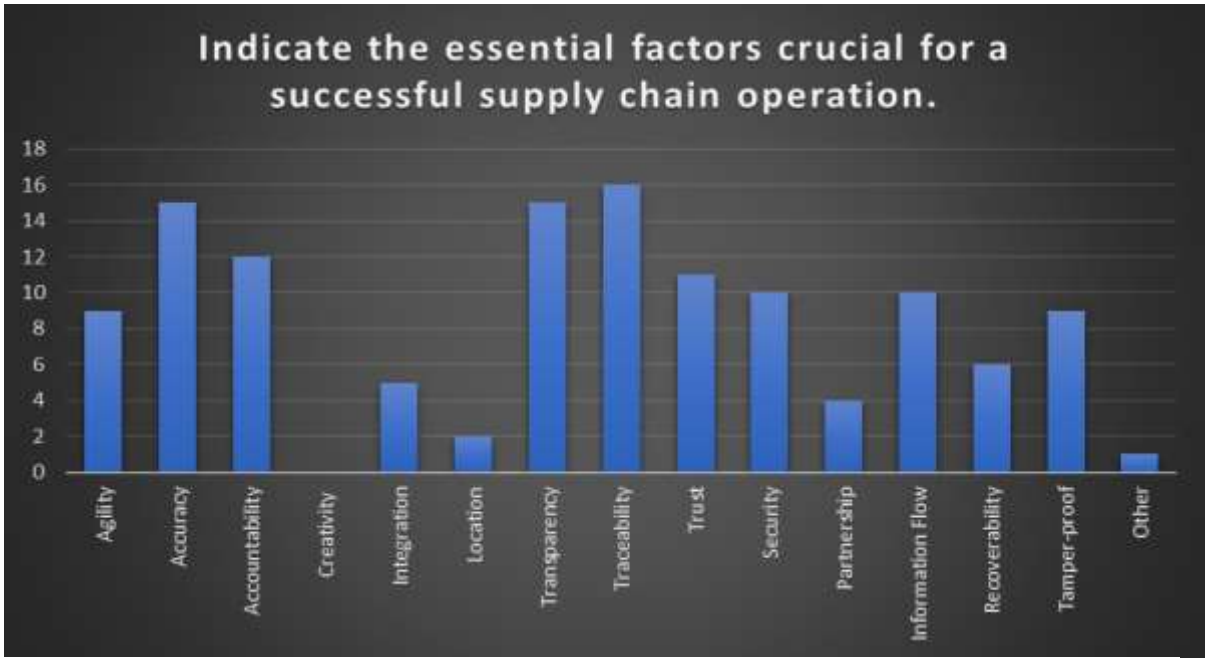

Figure 8: Critical success factors for supply chain

Traceability has been indicated as the most common critical factor essential for supply chain operations with 89% of respondents choosing this option. With a selection rate of 83%, both accuracy and transparency are one of the top three factors for successful supply chain operations. Accountability, trust, security, and information flow were selected by over 50% of respondents. One respondent indicated another option which was not visible, integrity. No participants chose creativity with only 2 participants selecting location.

What is interesting about the above result, supply chain literature is revolving around the integration and connectivity of other partners within that chain to ensure the correct information and traceability possibilities are maintained, however, with only 5 participants selecting integration and 4 selecting partnership, the need to have a full chain of open communication is not see as necessary to operate a successful supply chain.

5.2.6 Question 6: Have you heard of Blockchain technology?

This research base is to understand if knowledge of blockchain exists currently in the Irish food sector. The below graph indicated that over half of the respondents did not know of blockchain previously. This reduces the likelihood of potential plans for implementation in the future.

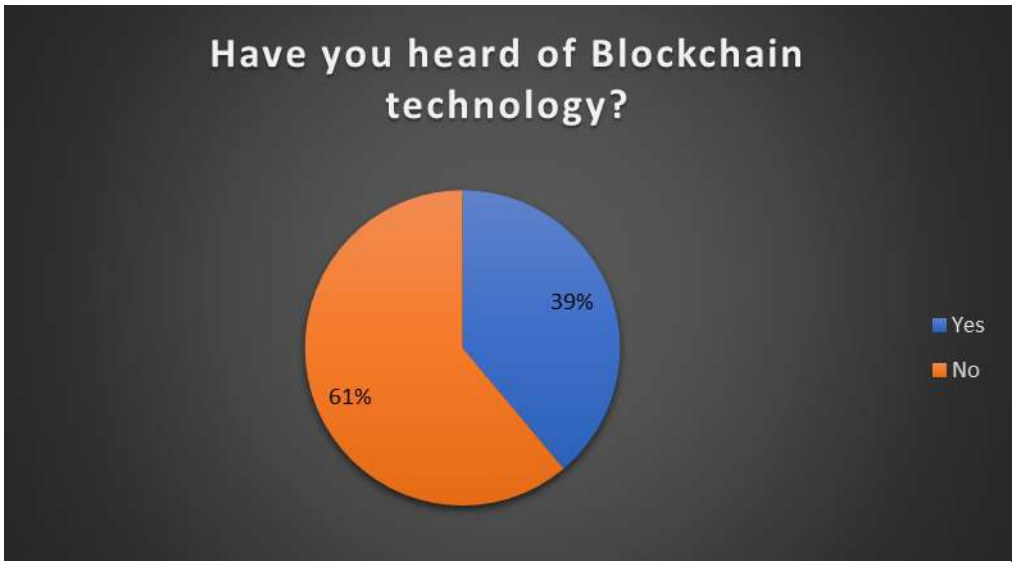

Figure 9: Blockchain understanding

5.2.7 Question 7: Has your company implemented Blockchain in an area of business? Is your company currently in progress of implementing Blockchain?

One organisation currently implemented or is currently implementing blockchain technologies within their organisation. This indicates that there is currently a process in operation where a company is implementing elements of blockchain into their organisation.

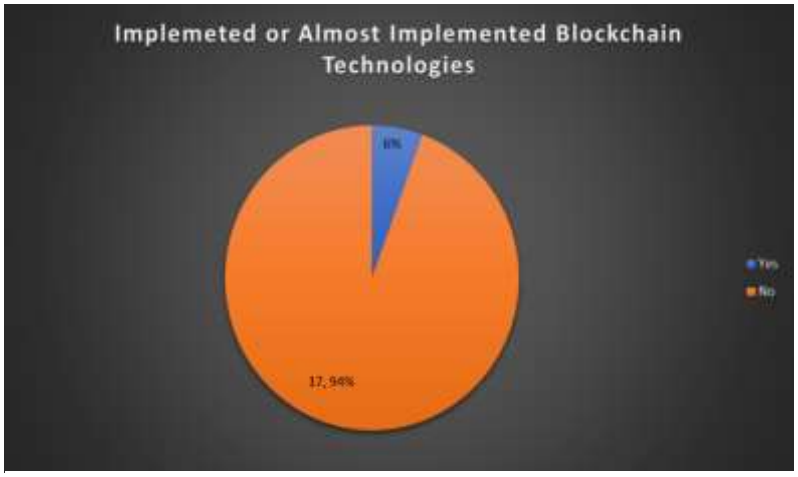

Figure 10: Implementation or part implementation of Blockchain

5.2.8 Question 8: Does your company plan to implement Blockchain within the next 1-5 years?

Over the coming 1-5 years, 11% of participants have indicated the potential implementation of blockchain within their organisation. The result of this question indicated companies are in progress of beginning a process for implementation for this technology into their organisations. This is a positive result as the range of participants and operational sectors are indicating a small element of implementation, this therefore suggests the full food sector contains companies implementing elements of blockchain. For such a new technology into the area of food, there would have to be some expected benefits a company would require classing successful implementation.

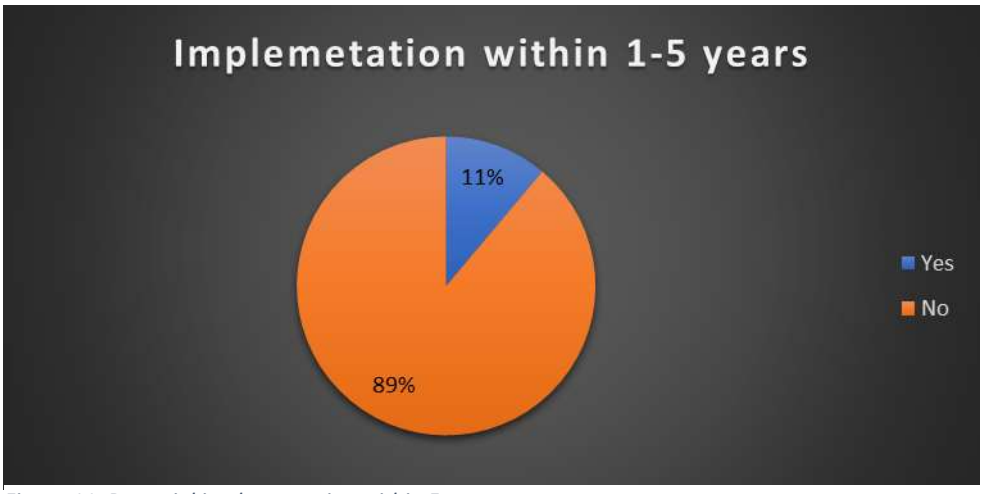

Figure 11: Potential implementation within 5 years

5.2.9 Question 9: The expected benefits for the implementation of Blockchain

There is an expectation of benefits from blockchain for many organisations exploring and implementing this technology. Benefits in traceability and security are the main focus points for implementation. Cost saving and data management methods are seen as expected benefits along with stock management and transparency. A wide variety of control and improvement measures are mentioned as the expected benefits from the implementation of this technology.

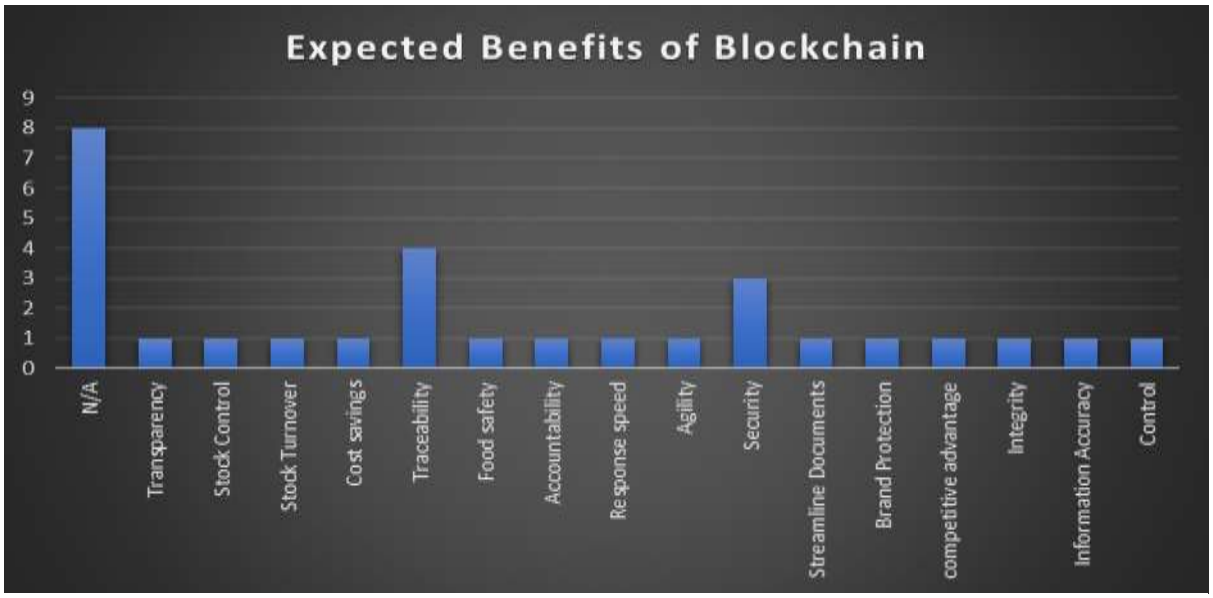

Figure 12: Expected benefits of Blockchain

5.2.10 Question 10: The essential operating factors for a successful computer system

Finally, in order to implement a computerised technology, the expected benefits of such a technology for its potential consumer is helpful in determining if it is the correct fit for that consumer. Participants in this study have indicated that accuracy and tamper-proofing are essential aspects of a computerised technology, followed by agility, accessibility, transparency, trust and recoverability.

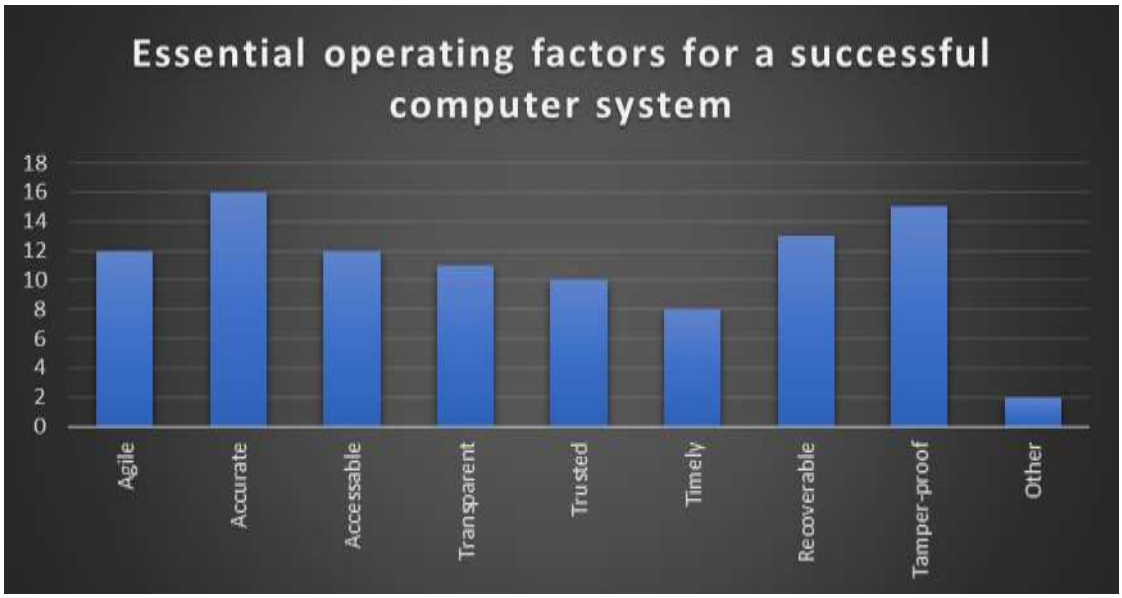

Figure 13: Critical success factors for computer systems

5.3 Discussion

The research question asked is aimed to determine the status of blockchain implementation in the Irish food industry. The primary question this study is focused on is to answer if there are blockchain implementations currently underway or complete within this Irish food industry? To fully answer this question, three other questions also have to be answered. Using the results of the conducted study, this paper has brought together the analysis and formed answers to the proposed questions from earlier in this paper.

Before the primary question is addressed, the sub-questions must be addressed.

5.3.1 Sub-question 1: Within the Irish food sector, do participants in supply chain know of the technology called Blockchain?

The research conducted asked individuals of their knowledge of Blockchain. It is clear to say over 61% of participants had not previously known of the technology called Blockchain. Understanding that this is a relatively new technology which has been around twelve years may play a part in the extended knowledge of individuals within this sector (Roy, et al., 2020). Blockchain has also branched out from other sectors such as finance, which may have slowed the technologies uptake, the implementation in other areas, or the knowledge of the benefits of this technology being sharing across sectors (Wang, et al., 2019).

This result does display that 39% of participants did hear of blockchain before this study was conducted. Although this is a small number, it is a positive view that this new technology's is known of and understood by some individuals and companies within the Irish food industry.

5.3.2 Sub-question 2: What are the expected factors which implement a successful operating supply chain, within the food industry?

As this study looks to evaluate the current implementation of blockchain within a supply chain functions of a food sector organisation, the expected benefits of a successful operating supply chain must be reviewed along-side the known benefits of blockchain implementation.

According to the participants of this study, the top five critical success factors for a successful supply chain operation are:

1. Traceability
2. Transparency
3. Accuracy
4. Accountability
5. Trust

These five success factors are mentioned across literature as requirements for building trust within a supply chain (Rana & Sharma, 2019). Many researchers discuss processed to improve trust, traceability, reactivity, transparency, and security throughout implementations such as enhanced RFID trackers, IoT, and other industry 4.0 techniques (Zelbst, et al., 2019). The ability to display these success factors is a demonstration to the overall security of this sector and provides the consumer with trust into the entire chains to know and understand where their product has come from and how it was made (Zelbst, et al., 2019).

The development and integration of a technology onto current traditional supply chain technology has the potential to enhance the above identified critical success factors for supply chain operations within a food sector. This could be blockchain technologies. Blockchains advantages include, but are not limited to, the above five success factors for supply chain. This enhances the potential overlap this technology could offer this business operations for future competitive advantage.

5.3.3 *Sub-question 3: What is the overlapping expected benefits between the operating of an efficient supply chain and an efficient computer system?*

Operating success factors of a supply chain do overlap with a computerised system. Understanding this will allow a reader to determine if it is possible to implement blockchain into a supply chain and maintain the desired critical operating factors to enhance a supply chains operation.

According to the results of this study, participants expect computer systems to be accurate, tamper-proof, and recoverable. This displays the need for trust in the data retrieved from that software. Participants then indicate agility and accessibility to complete the top five selections for a successful operating computer system. Although the only overlapping critical factor is accuracy, it is clear a sense of trust in data extracted from the source is required. The need for recoverable and tamper-proof information highlights the need for security with this type of software.

This being the opinion of participants, literature also highlights the need for security and trust when using an operating system (Khan & Salah, 2018). The need to ensure the end user of authenticity of a good or service results in the ability to produce a traceable chain of events that is transparent and unable to tamper with information throughout its supply chain, highlighting the need for security to build end user trust (Avilés-Sacoto, et al., 2019).

5.3.4 *Primary Question: Are there blockchain implementations currently underway or complete within the Irish food industry?*

It is clear that this study has identified over half of participants from this study within the food supply chains in Ireland have not heard of blockchain technologies before this study. This should not be seen as a failure. This highlights that this technology is not fully known and there is room to grow the industries knowledge of this technology and its potential benefits. Through this study the overlap of critical success factors between computerised systems and supply chain operating systems have been identified and assessed. The top five critical success factors for the implementation of successful supply chains are also identified.

To answer the primary question asked, within the next one to five years, some participants did indicate the intention of their company in currently planning an implementation of blockchain. The actual area of implementation was not specified, however, the indication of intent to implement means benefits of an implementation are expected.

One participant to this study indicated their company are currently working on or have completed an implementation of blockchain within their organisation. Again, with any implementation, there would be expected benefits. All participants were asked to indicate potential benefits expected from an implementation of blockchain technologies if this is a direction of their company. These benefits included improvements to data and information management, stock maintenance and controls, increases to their companies competitive advantage leading to cost saving measures, and increases to food safety and transparency which all have been indicated throughout literature of being potential benefits.

Stock control, stock turnover and cost saving measures are indicated as potential benefits through some blockchain supply chain studies completed (Avilés-Sacoto, et al., 2019). These benefits in the food industry do lead to improved accuracy and transparency of the inventory levels leading to a more agile, reactive, and controlled food safety practices which lead to lower levels of risk and increased information available to improve and monitor products as they pass through the supply chain (Abeyratne & Monfared, 2016). The increase in competitive advantage as a benefit was not highlighted in literature. This is an interesting observation of the study as it suggests a potential gain for brand management and awareness depending on the intended direction of the competitive advantage achieved by the organisation.

These benefits listed overlap with the benefits that a successful blockchain implementation can offer. It is clear that the food industry in Ireland does contain companies implementing blockchain technologies.

Chapter 6: Conclusion and Future Research

6.1 Limitations of this Study

This study was conducted during a time of difficulty for many companies. With the closure of much of the economy of Ireland, the month chosen to conduct this study resulted in a poor participation rate, potentially due to the level of uncertainty within the industry at the time. This industry remains as the highest export sector for Ireland but due to the economic impact of the current pandemic underway, some companies were unable to participate due to the area in the food sector they primarily sell, eg., hospitality industry.

This paper was conducted under a time limit which did not allow for further probing into areas of potential questioning derived from the study completed. The initial study tool chosen was deemed viable but on reflection, the ability to as multiple questions to allow for further probing into each area was not possible and should have been explored. This time limit did not also allow for the implementation of any interviews with members of the food industry further enhancing the results obtained.

6.2 Conclusion

Blockchain technologies are distributed ledgers which allow for the removal of third-party entities in the movement of information and transactions throughout the chain created (Kshetri, 2018). This technology aids in increasing transparency and traceability of all information inputted into its system (Kamilaris, et al., 2019). Each block is created, dated, time stamped, and connected to its location in a chain always ensuring the information inputted can be traced back to when, where, and how the data was inputted (Galvez, et al., 2018).

The study conducted has highlighted that there are some organisations within the Irish food industry that are currently implementing or plan to implement blockchain into their operations. This is due to the potential benefits of blockchain technology and the previous successes companies, such as Walmart, have received (Kamath, 2018). This technology is not widely known in this sector but could be growing due to the new popularity of this technology (Abeyratne & Monfared, 2016).

Food sector operations rely upon trust of the end user in order to maintain their organisational position. However, if this trust is damaged, it is likely to affect that organisations competitive position in the marketplace. This study has highlighted the requirements for a successful supply

chain in the food industry. Traceability, transparency, accuracy, accountability, and trust are all possible using blockchain technologies. These benefits have been highlighted multiple times from multiple academics as benefits for blockchain implementation (MahbubulHye, et al., 2020).

Although this study did not set out to identify growth potential for blockchain technologies, it is clear that with the overlap between the top five identified critical success factors for a supply chain operation with the benefits of a successful implementation of a blockchain, there is high potential for further implementations, explorations, and integrations using this technology alone or couples with an existing traditional technology to enhance an operations competitive advantage and increase cost savings throughout a supply chain.

As indicated in many academic reviews on blockchain technology, the implementation of blockchain technologies into a food sector has focused areas of study in North America and Asia (Yiannas, 2018). This study does highlight the potential implementations happening currently in the Irish food industry. Many companies in Ireland produce for use in domestic markets however, this industry is one of Irelands highest exporters, distributing product to the UK, Europe, and internationally across over 180 countries making it a potentially valuable area for improvement and exploration (FDI, 2020).

6.3 Recommendations for Future Work

It is clear that the knowledge of blockchain across the Irish food sector is limited. However, there are some indications of blockchain implementation into this sector. The data collected within this study only cover a small section of the food industry meaning there are more subsectors whose contribution could change the results of this study. Although this is a relatively new technology to the sector, there could be more implementation potential across the island of Ireland. This would present a potential area for future development to understand how these companies intend to implement the technology. There is also potential to complete another similar study capturing more potential participants within the Irish food sector to gain a further and deeper indication into the knowledge of all organisations in this area.

Bibliography

Abeyratne, S. A. & Monfared, R. P., 2016. Blockchain Ready Manufacturing Supply Chain Using Distributed Ledger. *International Journal of Research in Engineering and Technology,* 5(9).

Amin, M. R., Zuhairi, M. F. & Saadat, M. N., 2020. Enhanced Blockchain Transaction: A Case of Food Supply Chain Management. *Journal of Engineering and Applied Sciences,* 15(1), pp. 99-106.

Asgari, N., Nikbakhsh, E., Hill, A. & Farahani, R. Z., 2016. Supply Chain Management 1982-2015: a review. *IMA Journal of Management Mathmatics,* 27(3), pp. 353-379.

Avilés-Sacoto, S. V. et al., 2019. A glance of Industry 4.0 at supply chain and inventory managament. *International Journal of Industrial Engineering,* 26(4), pp. 486-506.

Bia, B., 2019. *Performance and prospects 2019 - 2020.* [Online]
Available at: https://www.bordbia.ie/globalassets/bordbia.ie/industry/performance-and-prospects/2019-pdf/performance-and-prospects-2019-2020.pdf
[Accessed July 2020].

Blossey, G., Eisenhardt, J. & Hahn, G. J., 2019. *Blockchain Technology in Supply Chain Management: An Application Perspective.* s.l., s.n.

Bryman, A. & Bell, E., 2011. *Business research methods.* 3rd ed. s.l.:Oxford University Press.

FDI, 2020. *Food Industry.* [Online]
Available at: https://www.fooddrinkireland.ie/Sectors/FDI/FDI.nsf/vPages/Food_Industry~sector-profile!OpenDocument
[Accessed July 2020].

Fernando, E. et al., 2018. Critical Success Factor of Information Technology Implementation in Supply Chain Management: Literature Review. *5th International Conference on Information Technology.*

Galvez, J. F., Mejuto, J. & Simal-Gandara, J., 2018. Future challenges on the use of blockchain for food tracability analysis. *Trends in Analytical Chemistry,* Volume 107, pp. 222-232.

Jia, F., Zuluaga-Cardona, L., Bailey, A. & Rueda, X., 2018. Sustainable supply chain management in developing countries: An analysis of the literature. *Journal of Cleaner Production,* Volume 189, pp. 263-278.

Kamal, M. M. & Irani, Z., 2014. Analysing supply chain integration thorugh a systematic literature review: a normative perspective. *Supply Chain Management: An International Journal,* 19(5), pp. 523-557.

Kamath, R., 2018. Food Traceability on Blockchain: Walmart's Pork and Mango Pilots with IBM. *The Journal of British Blockchain,* 1(1), pp. 47-53.

Kamilaris, A., Fonts, A. & Prenafeta-Boldv, F. X., 2019. The Rise of Blockchain Technology in Agriculture and Food Supply Chains. *Trends in Food Science & Technology,* Volume 91, pp. 640-652.

Khan, M. A. & Salah, K., 2018. IoT security: review, blockchain solutions, and open challenges. *Future Generation Computer Systems,* Volume 82, pp. 395-411.

Kim, H. M. & Laskowski, M., 2017. Agriculture on the Blockchain: Sustainable Solutions for Food, Farmers, and Financing. *In: D. Tapscott (Ed.), Supply Chain Revolution, Barrow Books 2018.,* 17 December.

Kshetri, N., 2018. 1 Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management,* Volume 39, pp. 80-89.

Kumar, M. V. & Iyengar, D. N. C. S. N., 2017. A framework for blockchain technology in rice supply chain management. *Advanced Science and Technology Letters,* 146(22), pp. 125-130.

Kumar, S., Heustis, D. & Graham, J. M., 2015. The future of traceability within the U.S. food industry supply chain: a business case.. *International Journal of Productivity and Performance Management,* 64(1), pp. 129-146.

Lambert, D., Robeson, J. & Stock, J., 2000. Issues in supply chain management. *Industrial Marketing Management,* 29(1), pp. 65-83.

MahbubulHye, A. K. et al., 2020. Factors Affecting Block chain-Based Logistic Chain, Empirical Evidence in Logistic Supply Chain. *TEST Engineering & Management,* 83(3), pp. 8603-8612.

Mentzer, J. T. et al., 2001. Defining Supply Chain Management. *Journal of Business Logistics,* 22(2), pp. 1 - 25.

Nakandala, D., Lau, H. & Zhao, L., 2017. Development of a hybrid fresh food supply chain risk assessment model. *International Journal of Production Research,* 55(14), pp. 4180-4195.

Ocicka, B. & Razniewska, M., 2018. Food waste reduction as a challenge in supply chain management. *LogForum,* 14(4), pp. 549-561.

Perboli, G., Musso, S. & Rosano, M., 2018. Blockchain in logistics and supply chain: a lean approach for designing real-world use cases. *IEEE Access,* Volume 6, pp. 62018-62028.

Queiroz, M. M., Telles, R. & Bonilla, S. H., 2020. Blockchain and supply chain management integration: a systematic review of the literature. *Supply Chain Management: An International Journal,* 25(2), pp. 241-254.

Rana, K. & Sharma, S. K., 2019. Supply Chain Performance Measurement: A Scale Development. *The IUP Journal of Business Strategy,* XVI(1), pp. 88-111.

Rogerson, M. & Parry, G. C., 2020. Blockchain: case studies in food supply chain visibility. *Supply Chain Management: an International Journal,* 25(5), pp. 601-614.

Roy, S. K., Ganguli, R. & Goswami, S., 2020. Transformation of Supply Chain Provenance Usng Blockchain - A Short Review. *Advances in Intelligent Systems and Computing ,* Volume 937, pp. 583 - 593.

Saberi, S., Kouhizadeh, M., Sarkis, J. & Shen, L., 2018. Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research,* 57(7), pp. 2117-2135.

Saunders, M., Lewis, P. & Thornhill, A., 2019. *Research methods for business students.* 5th ed. s.l.:Pearson Education Limited.

Tian, F., 2017. *A supply chain traceability system for food safety based on HACCP, blockchain, and Internet of things.* Dalian, China, IEEE Conference Publication.

Tse, D. et al., 2017. Blockchain Application in Food Supply Information Security. *IEEE International Conference on Industrial Engineering and Engineering Management,* pp. 1357-1362.

Wang, Y., Han, J. H. & Beynon-Davies, P., 2019. Understanding Blockchain Technology for Future Supply Chains: A Systematic Literature Review and Research Agenda. *Supply Chain Management: an International Journal,* 24(1), pp. 62-84.

Wu, H. et al., 2017. A Distributed Ledger for Supply Chain Physical Distribution Visibility. *Information,* 8(137), pp. 1-18.

Yadav, S. & Singh, S. P., 2019. Blockchain critical success factors for sustainable supply chain. *Resources, Conservation & Recycling,* Volume 152.

Yiannas, F., 2018. A new era of food transparency powered by blockchain. *Innovation,* 12(1-2), pp. 46-56.

Zelbst, P. J., Green, K. W., Sower, V. E. & Bond, P. L., 2019. The impact of RFID, IIoT, and Blockchain technologies on supply chain transparency. *Journal of Manufacturing Technology Management.*

Zhu, Q. & Kouhizadeh, M., 2019. Blockchain Technology, Supply Chain Information, and Strategic Product Deletion Management. *IEEE Engineering Management Review,* 47(1).

Abstract

1. Questionnaire Distributed:

The use of Blockchain in food supply chains in Ireland

This survey aims to understand the current implementation of Blockchain within the Irish food supply chain and to understand the main requirements for a successful supply chain. This research is being conducted as part of a final year masters dissertation for the Masters of Business Administration program run by the National College of Ireland.

This survey is entirely anonymous, and the data collected will be protected and stored securely. This survey consists of 10 questions and will take 5-minutes to complete.
Thank you for your time and the information you have provided.

Blockchain is a distributed digital ledger which created a chain of data, each linked to the last to securely and effectively complete transactions. More famously knows for its use within the cryptocurrency markets, Blockchain has grown in popularity within finance, healthcare, retail, and logistics areas, due to the technologies ability to display full transparency on all transactions complete through its unique ability to link each piece of data together.

Organisations worldwide are implementing Blockchain technologies across business processes to improve efficiencies, collaboration, accountability, and transparency. As information passed along a Blockchain cannot be destroyed, and history for all data exists, full traceability on each data block is possible.

* 1. What area of the food industry does your company mainly operate?

* 2. Which of the following best describes your current job level?

- Owner, C-level, Executive
- Senior level management
- Middle management
- Employee
- Consultant
- Temporary staff
- Other

* 3. Supply chains in the food industry are trusted, accessible and transparent.

Strongly agree | Agree | Neither agree nor disagree | Disagree | Strongly disagree

* 4. Supply chains in the food industry are secure, and information is tamper-proof.

Strongly agree | Agree | Neither agree nor disagree | Disagree | Strongly disagree

* 5. Indicate the essential factors crucial for a successful supply chain operation.

- [ ] Agility
- [ ] Accuracy
- [ ] Accountability
- [ ] Creativity
- [ ] Integration
- [ ] Location
- [ ] Transparency
- [ ] Other (please specify)
- [ ] Traceability
- [ ] Trust
- [ ] Security
- [ ] Partnership
- [ ] Information Flow
- [ ] Recoverability
- [ ] Tramper-proof

* 6. Have you heard of Blockchain technology?

( ) Yes ( ) No

* 7. Has your company implemented Blockchain in an area of business? Is your company currently in progress of implementing Blockchain?

( ) Yes ( ) No

* 8. Does your company plan to implement Blockchain within the next 1-5 years?

( ) Yes ( ) No

* 9. Please indicate in the text box below, the expected benefits for the implementation of Blockchain?

* 10. Indicate the essential operating factors for a successful computer system?

- [ ] Agile
- [ ] Accurate
- [ ] Accessable
- [ ] Transparent
- [ ] Other (please specify)
- [ ] Trusted
- [ ] Timely
- [ ] Recoverable
- [ ] Tamper-proof