Understanding blockchain deployments in supply chains: A Template Analysis

M Hinchliffe

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Abstract

This research is a response to Treiblmaier et al. (2021) who called for future research into blockchain adoption in supply chains that produce actionable outcomes which may be used by industry and academia to understand the blockchain deployment process. This is achieved through an adapted version of the Technology-Organisation-Environment theoretical framework, by first understanding the barriers which organisations face when they attempt to deploy a production-grade blockchain throughout their supply chain, before detailing novel best practices currently being employed in industry that target the underlying causes of the barriers identified in the first part of the research. In this Critical Realist interview study, evidence was collected from 18 participants who each had extensive experience working with blockchain technology in a supply chain setting. Further, in response to Treiblmaier et al. (2021), a maximum variation sampling approach was undertaken to capture the perspectives of various key stakeholder groups. Additionally, several interviewees had worked on production-grade blockchain deployments which are infrequently documented in the extant literature. Template Analysis was the preferred data analysis method due to its compatibility with the Technology-Organisation-Environment theoretical framework and its flexibility to be applied with various philosophical assumptions and research methods. The Template Analysis revealed that the interviewees found 'onboarding supply chain members into the blockchain governance' and 'establishing the return on investment from the blockchain project' were the two most prominent issues facing blockchain deployments throughout a supply chain. Thus, best practices were identified which targeted the underlying causal mechanisms which caused each of these barriers to occur. This was presented as a framework in the form of a series of tables which can be used by managers to aid in their blockchain deployments whilst being the basis for future academic research.

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Declaration

I, the author, confirm that the Thesis is my own work. I am aware of the University's Guidance on the Use of Unfair Means (www.sheffield.ac.uk/ssid/unfair-means). This work has not been previously been presented for an award at this, or any other, university.

1. Introduction

The importance of security in establishing a digital currency has long being established. In 1997 Nick Szabo published an article titled 'The God Protocols' (Szabo, 1997). Szabo was aiming to highlight the idea of a "be-all end-all technology protocol" that would ensure the validity of each transaction (Tapscott & Tapscott, 2018, p5). In 2008, Nakamoto (2008) developed Blockchain, the first working form of the technology protocol hypothesised by Szabo (1997). Before 2008, digital currencies were subject to the double-spending problem, whereby a single coin could be spent more than once. Historically the solution to this problem was to use a centralised authority that would verify that each coin was only spent once. In 2008 a solution to the double-spending problem was published by Nakamoto (2008) along with the invention of the first internet-bound cryptocurrency, Bitcoin. This was achieved through the development of Blockchain, the technology underpinning Bitcoin and other cryptocurrencies. The solution was to develop a publicly accessible decentralised ledger that operates in a peer-to-peer network; using advanced cryptography to ensure the data within the ledger was tamperproof. Originally, this was achieved through the consensus mechanism proof-of-work, which was built into the blockchain to ensure the maintenance of the true state of the ledger. As a result, blockchain can be considered a technological advancement of the traditional ledger as the historical purpose of the ledger has been to ensure legitimation of recordings of ownerships, agreements, and transactions (Davidson et al., 2018). Each node within the network has a copy of the ledger, and - assuming trust in the consensus mechanism - each agent in the network can trust the data within the ledger is true. Despite the advent of cryptocurrencies, several scholars reason that the true innovation of Nakamoto (2008) is in the creation of the blockchain platform. This is perhaps best evidenced in the opening line of the blurb of Swan's (2015) much-cited book, *'Blockchain: Blueprint for a new economy'*, that reads "Bitcoin is starting to come into its own as a digital currency, but the blockchain technology behind it could prove to be much more significant".

There is still debate over the type of technology blockchain is and the type of value which blockchain will create (Davidson et al., 2018). Some view blockchain technology as a Schumpeterian technology that will provide productivity improvements to already established operations (Mougayar, 2016; Schumpeter, 1942; Swan, 2015; Tapscott & Tapscott, 2018). Alternatively, others consider the value offered by blockchain technology to be Coasian in that it can remove transaction costs to fundamentally alter how economies and markets function (Catalini & Gans, 2016; Coase, 1937, 1960). Despite this debate over blockchains long-term value, large sample survey data shows that an overwhelming majority of senior executives in industry believe blockchain will be "very/ somewhat important" in the short-term future (Deloitte, 2021). Similarly, a large quantity of academic research has been conducted looking into motivations and deterrents of blockchain technology adoption in supply chains (Bhardwaj et al., 2021; Chittipaka et al., 2022; Deng et al., 2022; Hader et al., 2021; Lin, 2023; Oguntegbe et al., 2022; Orji et al., 2020; Suwanposri et al., 2021; Taherdoost, 2022). Thus, there is a need to understand how organisations go about undertaking the deployment of a blockchain project. Despite this, few studies have aimed to understand the process of deploying blockchain technology throughout a supply chain. As a result, there is a disconnect between real world blockchain adoption in a supply chain use case and the academic literature. This research aims to bridge this gap by understanding how organisations can work with their supply chain to deploy a blockchain system throughout their supplier base. This is achieved through first understanding the barriers which organisations face when they attempt to deploy a blockchain throughout their supply chain, before understanding some novel solutions and best practices which can be implemented in order to alleviate some of the challenges identified in the first part of this research. As a result, this research poses three research questions:

Research Question 1: What are the inhibitors to the successful deployment of a blockchain throughout a supply chain?

Research Question 2: How do causal mechanisms cause the inhibitors to the successful deployment of a blockchain throughout a supply chain to occur?

Research Question 3: What are the actionable best practices which can be implemented to mitigate the most prominent inhibitors to the successful deployment of a blockchain throughout a supply chain?

This research captures the in-depth first-hand experiences of industry professionals who have experience working to deploy blockchain solutions throughout a supply chain. This accounts for limitations in prior research that do not require experience working with blockchain technology to be involved with the research (eg Kamble et al., 2019; Nayal et al., 2021; Wong et al., 2020a; Wong et al., 2020b). Further, this research captures the perspectives of actors who work in various roles within the blockchain deployment project – Deployment Lead, Technology Provider, Advisor, Supply Chain Member - providing a new insight into how different agents within the network perceive the challenges to blockchain deployment projects. Thus, recommendations are made to academics and industry about best practices which can be actioned to mitigate challenges encountered when attempting to deploy a blockchain throughout a supply chain, and they are grounded in the real-world experiences of industry leaders with working with blockchain technology.

This is achieved through the lens of the theoretical framework being applied within this study and the ontological and epistemological assumptions being made in this research. As is highlighted in the literature review and the theoretical framework chapters respectively, there is a disconnect between the forms of trust being discussed in relation to blockchain research and the forms of trust being researched within the interorganisational trust literatures. This research aims to account for this difference by including integrity-based trust and competence-based trust, commonly discussed in the interorganisational trust literatures (Connelly et al., 2018; Grafton & Mundy, 2016; Lui & Ngo, 2004; Poppo et al., 2015; Tomkins, 2001; Zhong et al., 2017), with an adapted version of the technology-organisation-environment (TOE) framework (based on the work of Saberi et al., 2019), which is frequently incorporated within blockchain adoption in supply chain literatures (Bag et al., 2022; Barnes III & Xiao, 2019; Bhardwaj et al., 2021; Chittipaka et al., 2022; Deng et al., 2022; Fernando et al., 2021; Ganguly, 2022; Hader et al., 2021; Holotiuk & Moormann, 2018; Kouhizadeh et al., 2021; Kulkarni & Patil, 2020; Malik et al., 2021; Orji et al., 2020; Saberi et al., 2019; Schmitt et al., 2019; Seshadrinathan & Chandra, 2021; Suwanposri et al., 2021; Xia et al., 2022), but applies the framework in a novel way to understand the blockchain adoption process as opposed to the antecedents of blockchain deployment. This research also features ‘trust in technology’ as a construct which is a mode of trust which is documented within several journal articles which focus on blockchain adoption throughout

supply chains (Francisco & Swanson, 2018; Lu et al., 2021; Nayal et al., 2021; Wang et al., 2019; Wong et al., 2020b). As a result, this research increases the specificity of the blockchain adoption literary body by differentiating between three different modes of trust that are each documented within the relevant extant literature.

1.1. Important context surrounding blockchain technology

When researching blockchain technology and how organisations can work with blockchain technology, it is important to understand the context of blockchain technology at the time of the data collection within said research (Treiblmaier et al., 2021). As a result, the remainder of this section delineates two relevant factors surrounding blockchain technology at the time of this study. (1) the various types of blockchain technology; and (2) the technological context surrounding blockchain. In his conceptual paper on blockchain architectures, O'Leary (2017) outlines several distinctions that can differentiate between blockchain types. The three main differentiating forms of blockchain highlighted are; public versus private, permissioned versus permissionless, and peer-to-peer versus cloud-based. O'Leary (2017) reasons that organisations traditionally transact in ways where information asymmetries are present. As a result, the author proposes that blockchain architectures in the supply chain and accounting use cases are generally private, centralised, and cloud-based. Because this research seeks to understand challenges organisations face when they deploy a blockchain throughout a supply chain, this research is not specifically concerned with any specific type of blockchain. However, as noted by O'Leary (2017), the majority of use cases in supply chain management and accounting disciplines are private, permissioned, cloud-based blockchain protocols. As a result, it would be expected that the weighting of papers which are reviewed, and the cases which are studied within this thesis, is favoured toward private, permissioned, cloud-based blockchains.

It is important to note that blockchain is not developing in isolation and that other technologies are also evolving simultaneously. This is significant as advancements in one technology may impact the relevancy of all blockchain publications made prior to the

advancement. These technologies could end up replacing, complementing, or attacking blockchain. One example is quantum computing which could ultimately be able to effectively attack blockchains and render them as being unsecure (Fedorov et al., 2018), whilst others have argued that combining blockchain with quantum computing may be a way of improving the security of blockchain systems (Rajan & Visser, 2019). As a result, the relevancy of all blockchain-based publications is contingent advancements in other technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and robotics (Davidson et al., 2018; Lopes & Alexandre, 2018; Lopes, Alexandre, & Pereira, 2019; Swan, 2015). This means that different technologies, throughout the lifecycle of blockchain, could be viewed as governing variables in determining the development rates of blockchain. This is especially relevant for this research as the objective is to understand how blockchains can best be deployed throughout a supply chain, which is dependent on the supporting technologies which will be used to increase the functionality of the blockchain system.

2. Literature review

Several journal article databases were used to search for the relevant literature. The primary databases used to search for journal articles were Google Scholar and The University of Sheffield's StarPlus. The identified literature was then expanded by conducting searches in the databases of specific reputable journals. Reputability of journal articles was established according to the SCImago Journal and Country Rank (SJR) journal publication metric. The SJR measurement is derived from indicators which are applied to the Scopus journal article database, which aims to account for the frequency of citation and quality of the journal articles (SCImago, n.d.). Journals were identified from the 'Business and International Management', 'Business, Management and Accounting (miscellaneous)', and 'Renewable Energy, Sustainability and the Environment' categories. The category of 'Renewable Energy, Sustainability and the Environment' was included because of the frequency with which blockchain technology is discussed in the context of sustainable supply chain management in the extant literature. The journals where a specific search

within the journals was conducted included, but was not limited to, journals such as the International Journal of Production Economics and the Journal of Cleaner Production. The literature was identified through searches using keywords such as 'blockchain', 'blockchain adoption', 'blockchain supply chain', and 'blockchain technology organisation environment'. The narrow choice of key words was to ensure that the literature which was found through the search was closely tied to the research questions within this thesis. As a result, words such as 'cryptocurrency' and 'Bitcoin' were omitted from the searches due to their application of blockchain technology not being directly relevant to the supply chain use case. The searches were conducted between 2020 and late 2023.

Once the relevant literature was identified, it was reviewed using a five-step systematic approach: (1) The abstract and conclusions of the journal articles were read to establish the relevancy of the journal article to the research questions. (2) Articles which were deemed relevant to the research questions were read in full using a line-by-line approach. All articles which were read in full were then evaluated according to the research questions within this study to understand their relevance to this thesis. Articles which were not considered directly relevant to the research questions were grouped in various files which included peripheral literatures while directly relevant articles were grouped within a single file. (3) All journal articles which had been identified as directly relevant to the research questions were reviewed using the aid of a template to structure the review. The chosen template was a derivative of the Pitch Template which was developed by Faff (2015). The Pitch Template aimed to allow a reader to extrapolate key information from their own research publication, in order to allow them to discuss the key points from their research in a concise manor (Faff, 2015). This template was then adapted by Salehudin (2017) who tailored the template to be suited for reviewing journal articles of others. The template included 11 categories which were used to divide the key themes and methods into distinct categories – such as 'Research Question', 'Motivations', 'What's New', and 'Data'. However, to increase the suitability to this research, the template was adapted to include including an additional 2 subcategories – 'Limitations' and 'Quotes'. This increased the value the review would have when revisiting the document to ensure that all of the relevant considerations were captured. As an example, the completed review of the work of Kouhizadeh et al. (2021) is included in Appendix A using the adapted Salehudin (2017) template. (4) Steps 1-3 were

then repeated for key literatures which were cited within these journal articles but which did not appear through the database searches. (5) The contents of each journal article were then compiled into an Excel database according to the themes which were discussed within the paper. Consistent with the TOE theoretical framework being applied in this research, the themes were separated into the Technology, Organisational, and Environmental constructs. Each category was differentiated into subconstructs. Table 1 presents each of the themes, derived from the TOE framework, alongside the journal articles where the themes are discussed. These subconstructs, and the journal articles which discuss these themes, form the structure of this thematic literature review. However, some closely related subconstructs within the table are discussed simultaneously in this literature review. For example, financial constraints and workforce resources are presented separately in Table 1, but they are discussed simultaneously under the title of Organisational Readiness within this thematic literature review. Subconstructs were merged together in instances where one of two criteria would be met: (1) The review of the themes from the literature could create repetition due to the similarity between the two overlapping subconstructs, or (2) there is a convention of grouping specific subconstructs together within the extant literature.

Table 1: Themes from the TOE framework alongside journal articles where the themes are discussed

Category	Subconstruct	Discussed in:	Discussion frequency
Technology	Data collection	(Clohessy & Acton, 2019; Duan et al., 2020; Ganguly, 2022; Hastig & Sodhi, 2020; Kamble et al., 2019; Treiblmaier et al., 2021; Van Hoek, 2019; Wang et al., 2019; Wong et al., 2020a; Wong et al., 2020b)	10
	Integration	(Clohessy et al., 2020; Ganguly, 2022; Hastig & Sodhi, 2020; Kamble et al., 2019; Yadav et al., 2020; Treiblmaier et al., 2021; Van Hoek, 2019; Wang et al., 2019; Wong et al., 2020a)	9
	Scalability	(Biswas & Gupta, 2019; Clohessy et al., 2020; Duan et al., 2020; Hastig & Sodhi, 2020; Kamble et al., 2019; Kouhizadeh et al., 2021; Yadav et al., 2020; Treiblmaier et al., 2021; Van Hoek, 2019; Wong et al., 2020a; Zhao et al., 2019)	11
	Security	(Biswas & Gupta, 2019; Clohessy & Acton, 2019; Clohessy et al., 2020; Duan et al., 2020; Ganguly, 2022; Hastig & Sodhi, 2020; Kamble et al., 2019; Kouhizadeh et al., 2021; Saberi et al., 2019; Yadav et al., 2020; Treiblmaier et al., 2021; van Hoek, 2019; Wang et al., 2019; Wong et al., 2020a; Wong et al., 2020b; Zhao et al., 2019)	16
	Sustainability and energy	(Biswas & Gupta, 2019; Hastig & Sodhi, 2020; Kamble et al., 2019; Nayal et al., 2021; Saberi et al., 2019; Yadav et al., 2020; Van Hoek, 2019; Zhao et al., 2019)	8

Organisation	Financial resources	(Biswas & Gupta, 2019; Clohessy & Acton, 2019; Clohessy et al., 2020; Duan et al., 2020; Francisco & Swanson, 2018; Ganguly, 2022; Hastig & Sodhi, 2020; Kouhizadeh et al., 2021; Nayal et al., 2021; Saberi et al., 2019; Saurabh & Dey, 2021; Yadav et al., 2020; Treiblmaier et al., 2021; Van Hoek, 2019; Wang et al., 2019; Wong et al., 2020a; Zhao et al., 2019)	17
	Upper management support	(Clohessy & Acton, 2019; Clohessy et al., 2020; Francisco & Swanson, 2018; Ganguly, 2022; Hastig & Sodhi, 2020; Kouhizadeh et al., 2021; Nayal et al., 2021; Saberi et al., 2019; Treiblmaier et al., 2021; Wong et al., 2020a)	10
	Workforce resources and blockchain competencies	(Clohessy & Acton, 2019; Clohessy et al., 2020; Duan et al., 2020; Francisco & Swanson, 2018; Ganguly, 2022; Hastig & Sodhi, 2020; Kamble et al., 2019; Kouhizadeh et al., 2021; Nayal et al., 2021; Queiroz & Fosso Wamba, 2019; Saberi et al., 2019; Treiblmaier, Abderahman, et al., 2021; Van Hoek, 2019; L.-W. Wong et al., 2020; L. W. Wong et al., 2020a; Zhao et al., 2019)	16
	Unknown return on investment	(Clohessy & Acton, 2019; Clohessy et al., 2020; Francisco & Swanson, 2018; Ganguly, 2022; Hastig & Sodhi, 2020; Nayal et al., 2021; Queiroz & Fosso Wamba, 2019; Yadav et al., 2020; Treiblmaier et al., 2021; Wang et al., 2019; Wong et al., 2020a; Wong et al., 2020b)	12

Environment	Governmental policy	(Biswas & Gupta, 2019; Clohessy & Acton, 2019; Clohessy et al., 2020; Duan et al., 2020; Ganguly, 2022; Hastig & Sodhi, 2020; Kouhizadeh et al., 2021; Nayal et al., 2021; Oguntegbe et al., 2022; Reddick et al., 2019; Saberi et al., 2019; Saurabh & Dey, 2021; Yadav et al., 2020; Treiblmaier et al., 2021; Wang et al., 2019; Wong et al., 2020a; Wong et al., 2020b; Zhao et al., 2019)	18
	Collaboration	(Clohessy & Acton, 2019; Clohessy et al., 2020; Duan et al., 2020; Wamba et al., 2020; Francisco & Swanson, 2018; Ganguly, 2022; Hastig & Sodhi, 2020; Kouhizadeh et al., 2021; Nayal et al., 2021; Queiroz & Wamba, 2019; Saberi et al., 2019; Saurabh & Dey, 2021; Yadav et al., 2020; Treiblmaier et al., 2021; van Hoek, 2019; Wang et al., 2019)	16

2.1. Technological context

2.1.1. Blockchain security

Prior to 2019, there were very few publications which conducted empirical research on blockchain technology in supply chain management. Instead, the academic literature on blockchain application was predominantly focused on cryptocurrencies. However, Saberi et al. (2019) conducted a literature review with the purpose of developing a framework for blockchain adoption in supply chains. The authors attempted to gain insights into blockchain in supply chains by extrapolating findings from the cryptocurrency literature and applying these to a new context. As a result, the majority of the literature which was being used to develop the framework of barriers drew upon relevant discussions and events that occurred in cryptocurrencies, and the authors sought to apply that to supply chain management. The authors noted how data security was a concern with blockchain technology as there had been several successful attacks on cryptocurrency networks. The authors also stated there is a need for further research into proposed blockchain security solutions, as if the technology is unsecure, or is not perceived as being secure, then this will inhibit blockchain adoption in supply chain management. As a result, the authors classified data security as being one of the systems barriers which need to be addressed in order for blockchain to be successfully adopted in supply chain management.

Conflicting with Saberi et al. (2019), the early empirical research of Kamble et al. (2019) suggests data security is not a prominent issue facing blockchain technology. The authors conducted survey research of industry practitioners to try and understand perceptions toward blockchain technology adoption in industry. The insights which can be gained into security in this study are limited as the two hypotheses which involved data security were abandoned from the research due to them failing a construct validity test. Despite this, the authors used the other results to make inferences about data security. The authors concluded that the industry practitioners surveyed do not view blockchain technology as having any harmful consequences. Thus, security of the network is not viewed as an inhibiting barrier in industry to blockchain adoption. However, the divergence between the

findings of Saberi et al. (2019) and Kamble et al. (2019) may be a consequence of the skilled sample being surveyed in the Kamble et al. (2019) study as all of the participants had several years of experience in supply chain management and held post-graduate engineering degrees.

Like Kamble et al. (2019), Biswas & Gupta (2019) also conducted survey research into blockchain adoption barriers in the supply chain use case. However, unlike Kamble et al. (2019), Biswas & Gupta (2019) developed their survey based on the extant literature and pilot discussions with industry experts and academic experts to increase the validity of the questionnaire. From this, the authors identified ten prominent barriers to blockchain adoption in industry, outside of cryptocurrencies. Notably, the most frequently featured barrier from the literature review was risk of cyber-attacks; showing its prominence as a barrier to blockchain adoption. Following the literature review, Biswas & Gupta (2019) conduct a Decision Making Trial and Evaluation Laboratory (DEMATEL) analysis on the academic literature, to understand the influence that each barrier has on the other barriers. From the DEMATEL analysis, the authors categorise risk of cyber-attacks as a decisive barrier, meaning that it (1) has a high influence over other barriers, and (2) has a high quantity of interactions with other barriers. This means that the risk of cyber-attacks is one of the most prominent barriers to blockchain adoption as it is technological issue which needs to be addressed, and in doing so, would reduce the strength of other barriers to blockchain adoption. This finding supports the conceptual research of Saberi et al. (2019), whilst it is conflicting with the survey research of Kamble et al. (2019). This may be explained by the divergence in samples, or the fact that two of the data security hypotheses in the Kamble et al. (2019) study failed the validity test and as a result, do not capture the answers to the authors intended questions.

Unlike Kamble et al. (2019) and Biswas & Gupta (2019), Wang et al. (2019) conducted some early emergent, qualitative research into blockchain technology adoption in supply chain management. Due to the emerging nature of the field, the authors interviewed supply chain practitioners who had experience with IT generally as opposed to blockchain specifically. This approach accounted for limitations in the literary body as the majority of relevant studies at that time were either conceptual (Francisco & Swanson, 2018; Kokina et al., 2017; Saberi et al., 2019), or quantitative studies (Kamble et al., 2019; Queiroz & Wamba, 2019;

Reddick et al., 2019). The interview data showed that several of the supply chain experts believed blockchain technology offered intrinsic data security benefits over traditional systems. The security offered by blockchain systems was also discussed as a facilitator of trust in the solution itself as the immutability and transparency of the data on the blockchain can be observed, which can in turn expose any unethical actions or occurrences of inaccurate data in the supply chain network. However, whilst the participants did discuss blockchain and data security as a benefit of blockchain, they also highlighted certain new security-based barriers which become prevalent when operating with a blockchain system. Specifically, one interviewee noted how using a blockchain solution to disintermediate the supply chain, can remove a central authority which would traditionally have aided in dispute resolution. Additionally, the issue of data security in blockchain also includes blockchain permissions of who can access what data. In some cases, permissions on the blockchain may be ineffectively administered which could lead to sensitive information being shared which unintended individuals. There is also the threat of hacks which can put the data on the blockchain at risk. One interviewee notes how data security has to be considered from the perspective of each stakeholder in the network. Lastly, the authors conclude that data security should be researched in the context of supply chain governance. This qualitative research supports the quantitative evidence that blockchain is a security solution (Kamble et al., 2019), as opposed to a predominant barrier of adoption (Biswas & Gupta, 2019); however, it should be noted that the participants in the (Wang et al., 2019) study do not have to have experience working directly with blockchain technology.

Accounting for the limitations of prior research, van Hoek (2019) conducted mixed methods, survey and case study, research that sought to capture the perspective of individuals with first-hand experience in implementing blockchain systems in a supply chain industry setting. From their survey research, the author found that ‘drive to improve data and product security’ was the most prominent driver of blockchain adoption in supply chain management. This finding shows that there is a consensus amongst the supply chain professionals studied that blockchain can improve data and product security. However, using the same Likert-scale system, van Hoek (2019) also found that data security and data integrity concerns were significant barriers to blockchain adoption in supply chain management and they received a 4.6% lower mean rating. This suggests that whilst the

supply chain experts do view data security as the primary driver for blockchain adoption, there is still a consensus that there is a need for these security mechanisms to be further improved and tested before widespread adoption will take place. This is supported by how 'lack of data security on blockchains' was regarded as one of the least prominent barriers to blockchain adoption. However, contrasting the findings of their survey data, the case study portion of their research did not find security to be a driver of adoption, or a barrier to adoption. This is because the blockchains being used in the cases studied, were focused on operations such as transportation, or did not include consumer data. This finding suggests that there is a need to be specific about the objective of the blockchain which is being implemented, as different barriers will become more or less prominent based on the intended outcomes of the solution. The researcher also suggests that in blockchain pilots, where organisations are testing a blockchain solution on a localised scale, data security could be less of a consideration than it would be in a production-grade blockchain system. This finding extends upon the extant literature as it begins to explain how underlying conditions and circumstance can impact the challenges which an organisation may face when deploying a blockchain solution throughout a supply chain.

In one of several literature reviews conducted on blockchain technology published in 2020, Duan et al. (2020) conducted a literature review which included grey literature, focusing on the adoption of blockchain in agri-food supply chains. One of the insights from the literature review came when discussing scalability. The authors noted how several papers and influencers within the blockchain domain, discuss how scalability, security, and decentralisation, cannot all three be simultaneously achieved at one time (Ometoruwa, 2018; Perboli et al., 2018). The authors note how this dilemma could result in the scope of blockchain solutions in food supply chain being more limited, but that what is prioritised will depend on the objective or the requirement of the blockchain solution – supporting the insights of van Hoek (2019).

In their survey research, Wong et al. (2020a) include the factor 'complexity' to group a variety of technical considerations - one of which is security - into a single term. The authors find that complexity reduces the likelihood that organisations adopt blockchain, increases the cost of adoption, and does not increase the level of upper management support. Additionally, In their literature review which included cryptocurrency literature as well as

blockchain literature, Clohessy et al. (2020) found security to be one of the most prominent technological barriers to blockchain implementation in the extant literature. Notably, the authors define security barriers as being comprised of challenges concerning the data's vulnerability. The findings of Wong et al. (2020a) and Clohessy et al. (2020) suggest that if security causes the blockchain solution design to become increasingly complex, then this will increase the costs and reduce the likelihood of adoption. Thus, data security would be a causal mechanism of increased costs associated with the blockchain solution. Further, these findings in the context of the findings from the van Hoek (2019) study suggest that in blockchain projects where the objective involves securing highly confidential data, organisations may be more tentative about implementing a blockchain solution as a consequence of potentially increased costs throughout the development of the solution. However, the findings of Clohessy et al. (2020) are limited as they included cryptocurrency literature within their literature review, where the data is more vulnerable to attack given its monetary value, which could distort the insights into supply chain data. Conflicting these findings, the survey and structural equation modelling research of Wong et al. (2020b) finds that trust in the competence of blockchain technology, does not influence organisations to adopt blockchain technology in their supply chains. This suggests that other factors, specifically organisational factors, have a much greater impact on an organisations intention to adopt blockchain. However, the sample used in this study, whilst from a variety of industries, does not have familiarity with blockchain technology specifically, showing a potential lack of understanding of the technology. This is significant as it inhibits the level of insight which the participants can provide into the technology specifically, instead, showing their opinion on new technologies more generally.

Hastig & Sodhi (2020) conducted a literature review that concluded that data security was one of the critical success factors required for the successful implementation of blockchain technology. The authors categorised data security within technological readiness. One significant categorisation was the inclusion of the codes 'corruptible support technologies' and 'platform credibility'. These findings in conjunction suggest that when employing a digitalised approach where blockchain is supported by other technologies, this can improve the accuracy and value of the captured data and increase the credibility of the network; however, these technologies are also corruptible and they are points which a blockchain in a

supply chain could be attacked, without needing to hack the blockchain directly. This could also increase the complexity of the system as having several supporting technologies could cause integration issues, which could in turn reduce the desire to adopt multi-technology solutions (Wong et al., 2020a).

From a literature review which included empirical, theoretical, and grey literatures, and responses from a series of questionnaires, Yadav et al. (2020) identified a series of barriers to blockchain adoption in the Indian Agrifood sector. They then applied various analytical techniques to understand their interrelationships. The Interpretive Structural Modelling (ISM) analysis revealed a hierarchical tabulation of barriers, allowing for insight into which barriers drive the others. The authors found that lack of agri-stakeholder awareness and complexity of system design are drivers of security and privacy concerns. The fuzzy Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) analysis was another tool which allowed for the identified barriers from the literature review to be categorised based on their relationships with other barriers present in the study. Supporting the findings of the ISM, the fuzzy MICMAC analysis categorised security and privacy concerns as dependent barriers, meaning that whilst they are significant barriers, they are dependent on others. As a result, it is more efficient to tackle the driving barrier as this will then minimise the impact of security and privacy concerns. The authors found data and privacy concerns were driven by three other barriers: (1) lack of trust among agri-stakeholder perception, (2) lack of agri-stakeholder awareness and ease of use, and (3) 'complexity of blockchain system design'. As a result, this finding suggests that it is necessary to address the relationships with agri-stakeholders, and the complexity of the system design, as in doing so, this would be expected to minimise the impact of security concerns as a barrier.

In the quantitative part of their mixed methods study, Treiblmaier et al. (2021) conducted survey research using a sample of attendees of a supply chain management conference. The analysis of the survey data revealed that data privacy concerns and data security concerns were both found to be regarded as medium importance barriers amongst the sample studied. This finding conflicts with previous research that found data security to be a very significant barrier to blockchain adoption (Biswas & Gupta, 2019; Clohessy et al., 2020; Yadav et al., 2020) and research that found data security to not be a prominent challenge to blockchain adoption in a supply chain use case (Kamble et al., 2019; Van Hoek, 2019). Like

Yadav et al. (2020), Kouhizadeh et al. (2021) conducted a DEMATEL analysis into blockchain adoption. However, the data was obtained from a sample of academics and industry practitioners. The DEMATEL analysis revealed that security challenges were found to have the highest prominence values and that this was driven by technological immaturity and negative perception toward technology. However, conflicting with previous DEMATEL analyses (Yadav et al., 2020), security challenges was categorised as a mediating variable as it mediates the relationship immaturity of the technology has on the negative perception toward the technology. The authors conclude that this is especially prominent when the supply chain data which is being stored on the blockchain is sensitive. This suggests that the type of data which is being stored on the blockchain can impact the degree which security is a prominent barrier. This is consistent with the insights of Duan et al. (2020) and van Hoek (2019) who found that security was not a prominent concern in cases where the objective of the blockchain did not require data which was highly confidential.

It is important to recognise the major divergence in the results regarding data security. Sometimes data security is considered a key barrier (Biswas & Gupta, 2019; Clohessy et al., 2020; Yadav et al., 2020; Treiblmaier et al., 2021) whereas other times it is considered less important, to the point where it is not discussed as a barrier (Kamble et al., 2019; Van Hoek, 2019). Analysis between the studied literature suggests that this divergence seemingly occurs for two reasons: (1) The survey data collected in this domain is primarily of individuals who do not have first-hand experience implementing blockchain projects in supply chains. Alternatively, the limited number of case-based research studies do explore individuals accounts who have first-hand experience in implementing blockchain projects in supply chain management. Thus, as the relevant knowledge, experiences, and value the research participant can provide increases, the less likely they are to mention data security as a barrier. (2) Blockchain is often coupled with cryptocurrencies, even in literature which aims to focus on blockchains application specifically in supply chain management. This can be evidenced in the literature reviews within this field that use “bitcoin”, or “cryptocurrency” as a key search term, or who include literature which is focused generally on blockchain (Biswas & Gupta, 2019; Clohessy et al., 2020; Duan et al., 2020; Hastig & Sodhi, 2020; Saberi et al., 2019). This presupposes that the intended use of the blockchain and the data which it is storing, does not impact the barriers. However, in their respective

case-based research, Kouhizadeh et al. (2021) and van Hoek (2019) found evidence to suggest that the type of data which is being stored on the blockchain impacts the weighting and consideration that needs to be placed on each barrier. Further, this would suggest that the data type which is being stored is intrinsically linked to the type of blockchain that is being developed and the objective of the blockchain solution. As a result, data security, whilst still a concern, seems less of a concern in supply chains than it does in cryptocurrency networks, as the data which is being stored is of less value to a potential hacker. Further, there is a need for future research to differentiate between the various types of blockchain networks, in order to more accurately understand the barriers. Despite this, systems which use a variety of technologies alongside blockchain may need additional security measures to be taken to ensure that the supporting technologies are secure from corruption (Hastig & Sodhi, 2020).

2.1.2. Technological scalability

One of the most frequently discussed barriers to blockchain adoption in the literature is scalability. Kamble et al. (2019) surveyed supply chain professionals in their research to understand DLT adoption in supply chain management. In their study, they included 'discomfort' as a construct which was measured by four items. One of these measurements, 'blockchain designed for complex supply chains', can be related to scalability as it aims to measure how suited blockchain is to highly complex and large supply chains, which would inevitably require a large amount of scalability. These findings only permit a limited insight into scalability because only one of the four measurement tools are concerned with scalability, and that construct is focused around operational and supply chain scalability. Further, the sample does not have expertise in working with blockchain in supply chains as a requirement. However, the study can still provide some early insight into perceptions of the adoption of the technology amongst supply chain professionals. In the study the authors found that discomfort using blockchain technology does not impact ease of use or perceived usefulness. Thus, in the studied sample, discomfort associated with technological constructs was generally regarded to not impact how easy the blockchain is to use, or how valuable the

technology is. This suggests that the value of the technology is acknowledged amongst the studied supply chain professionals regardless of the difficulties associated with scaling the solution.

Accounting for research that doesn't include scalability as a single construct, Zhao et al. (2019) conducted a Thematic Analysis of blockchain adoption in the agri-food sector. One notable contribution of their literature review is that the authors categorised the findings according to the intended use and objective of the blockchain solution. Further, they also included the supporting technologies in their tabulation, accounting for the possibility that different assortments of technologies presenting different challenges. This is significant as they found that of the papers which focused on blockchain in the agri-food sector, scalability was only shown as a barrier in blockchain systems which aimed to improve data security. It should also be noted that the papers which identified this barrier, were focused on blockchain systems which were supported by IoT technologies. This could suggest that when large quantities of data are collected autonomously, scalability becomes a more prominent barrier than in less autonomous solutions. Scalability was prominent in the wider literature, which led them to identify scalability as one of six core barriers to blockchain adoption in the agri-food sector. The authors suggested two potential solutions to technological scalability challenges. Firstly, instead of storing the full original data, the blockchain could store an amalgamation of (1) metadata which provides information about the actual data, (2) critical data which is highly important data, and (3) hashes which can be used to identify the raw data. In this approach, the full original data would be stored elsewhere. Whilst this could improve storage on the blockchain which could in turn make it easier to scale the system, this does provide a new integration barrier in that the blockchain data and the original data need to be effectively integrated. Further, you may also realise less security benefit of blockchain as the raw data would no longer be secured by blockchain cryptography. The second possible solution was to use several sub-ledgers as opposed to one large singular ledger and to remove old transactions.

In van Hoek's (2019) mixed methods research, the author found that scalability of blockchain applications was shown to be a mid-level barrier. However, in the case study portion of the research, scalability was cited as being a major concern which could lead to unknown costs and an unknown return on investment. Specifically, scaling beyond the few

cooperating supply chain partners, to have a system which works with all suppliers could prove complex and expensive. However, scalability is discussed in all three cases as being a barrier which is a consequence of other barriers which become more prominent as you attempt to expand the scope of the blockchain system. For instance, as the project moves from a pilot towards a production-grade deployment, the cases cite factors such as interoperability, computing power, data accuracy, and supplier onboarding as being the main hurdles. One notable finding was the suggestion that different blockchain project objectives can make more some barriers more prominent. In a case looking at documenting upstream environmental footprint, the data must be inputted manually. As a result, the practitioners mention that supplier onboarding will be a more prominent barrier as it requires a greater level of continued work on behalf of the suppliers. This is discordant with the research of Zhao et al. (2019) that suggested when large quantities of data are collected autonomously, scalability becomes a more prominent barrier than in less autonomous solutions as a consequence of difficulty in capturing the required data. Alternatively, in systems where upstream data entry is autonomous, supplier onboarding may still be difficult, but easier because there is less burden on the supplier. This furthers the evidence that there is a need to increase the specificity of blockchain research in the supply chain use case by differentiating between the different types of blockchain solutions. One interesting distinction in the van Hoek (2019) study is that the survey data seemingly focused on technological scalability, whilst the case study research highlighted operational and supply chain scalability as being the most prominent concerns. This highlights a need for further research to explore operational and supply chain scalability. It is worth noting that this could be a result of the time when the case study data was collected as all three case studies were pilots which were currently attempting to scale into production-grade solutions. Thus, scalability may be a more prominent challenge when attempting to deploy a production-grade solution than at earlier phases of deployment.

Accounting for the limitations of previous survey research in the field, Biswas & Gupta (2019) conducted survey research with a small sample of experts who were currently working on implementing various DLT projects across a variety of sectors. Whilst the sample is small, the quality of the sample is very high considering the limited size of the qualified population. The DEMATEL analysis found that ‘challenges in scalability’ was the most

prominent barrier to DLT adoption of those studied. This is significant as the research accounted for several prominent barriers in the literature. The implication of this finding for industry is that managers need to effectively plan, evaluate, and address how they can effectively scale their DLT programme from its pilot state to a complete state. The use of the term 'challenges in' also suggests that this is not a purely technological form of scalability being discussed in the research, recognising the significance of the operational and supply chain challenges which are associated with scaling a blockchain system. This, in conjunction with van Hoek (2019), could be an indication that when conducting research with a sample which has experience in implementing blockchain projects, operational and supply chain issues become more prominent. Alternatively, when using a sample which does not have first-hand experience in scaling blockchain projects, that technological scalability could be overrepresented – perhaps due to its prevalence in the cryptocurrency literature.

Numerous literature review studies have been conducted which featured scalability as a construct (Clohessy et al., 2020; Duan et al., 2020; Hastig & Sodhi, 2020; Surendra Yadav et al., 2020). Clohessy et al. (2020) conducted a literature review which used "Bitcoin" and "adoption", and "Blockchain" and "adoption" as search strings. Thus, the research article took a generic approach to understand blockchain adoption and was not specific to any particular use of the technology. Whilst this approach expands the body of available literature which was necessary given the nascent nature of the technology, it also inhibits the specific insights which can be gained by narrowing the scope and focusing on a specific use-case or type of blockchain. The authors coded the literature and counted the instances of each code in order to gain a provisional insight into the prominence of different barriers facing blockchain technology adoption generally. Notably, of the included literature, scalability was one of the least prominent technological considerations with only 3 of the 31 papers mentioning it as an issue, whilst issues such as complexity were referenced in 2/3 of the literature. This divergence from other literature could perhaps be explained by their approach to undertaking the coding process as scalability in this research appears to be specifically concerned with the technological challenge of scaling the technology, and classifies factors associated with scalability separately. For instance, complexity, security, and compatibility are all prominent barriers in this research, and they are all shown to be exacerbated through the process of scaling in previous research. Likewise, Duan et al. (2020)

also conducted a literature review which led to them identifying scalability as one of the major barriers currently facing blockchain technology. Due to the nascent nature of the field, the authors included literature outside of the blockchain in agri-food domain and used this to contextualise the scalability to the agri-food industry. The authors identified scalability issues which are currently prominent in cryptocurrency blockchains as by increasing the number of transactions which can take place in the network, you reduce either the security of the network or the decentralisation of the network. Thus, at the highest end, scalability can become a very difficult problem to solve; however, it is important to acknowledge the differences between cryptocurrency blockchains and blockchains for supply chains.

Following their literature review, Hastig & Sodhi (2020) categorised scalability under the technological feasibility sub-theme. The authors stated that technological feasibility is currently a critical success factor which is required for the successful adoption of blockchain in supply chain management. The authors continue by linking the readiness of the technology for supply chains in 2020, to the relatively small number of organisations which currently use blockchain technology. The implication of this is that as technological constraints, such as scalability, are relieved as the technology matures, then more organisations will invest in the technology. Yadav et al. (2020) provided some insight into the development of the technology with their analysis of the literature and a series of interviews. They collected data from the Indian agricultural supply chain industry, and conducted interpretive structural modelling on a variety of barriers which were identified previously through a literature review and a series of discussions with experts. In their study scalability was specific to the technological capability of blockchain technology to scale. The ISM showed that 'scalability and speed' was largely influenced by 'complexity of system design' and 'lack of agri-stakeholder awareness and ease of use'. Likewise, the MICMAC analysis and the DEMATEL analysis both also categorised 'scalability and speed' as a dependent barrier. However, the value of this finding is limited in three main ways. Firstly, only ~14% of the experts involved in the study have experience implementing blockchain projects, which could inhibit the value of the findings. Secondly, in their provided definitions the authors infer that 'scalability and speed' are intrinsic technological properties of the technology, but then their findings show that they are most dependent on stakeholder

awareness and ease-of-use, which would be expected to have no influence over an intrinsic property. Thirdly, different blockchains have different cryptography and consensus mechanisms, which require different levels of computation power and storage, meaning that a singular value cannot be accurately placed on something with so much deviation. Despite this, this supports the insights provided by Zhao et al. (2019) which provided evidence that complexity of system design and the use of supporting IoT technologies, may make the scalability of the system a more prominent barrier and concern.

Kouhizadeh et al. (2021) focused on the technological properties of blockchain technology in their survey research. The authors included scalability as having two components – (1) challenges associated with processing large quantities of transactions, and (2) challenges associated with storage as the number of blocks and the size of the blocks continually increases. The authors performed a DEMATEL analysis on the survey data and found that the immaturity of the technology was a prominent barrier to blockchain adoption amongst academics and industry practitioners. Further, the analysis showed that security challenges mediate the relationship between technology immaturity and the negative perception toward the technology. Thus, it would be expected that as the technology becomes more mature, less data security issues would arise, which would reduce the negative perception toward the technology, which could increase blockchain implementation rates. Thus, it is necessary to ensure that the technology is as secure as possible, as this is a driver of one of the most prominent barriers to adoption.

Building on previous quantitative and qualitative research, Treiblmaier et al. (2021) conducted a mixed methods study into the organisational aspects of blockchain adoption. The survey data revealed that 'limited scalability' was a mid-level barrier to blockchain adoption; however, the predominant barriers revolved around 'lack of understanding' and such this may not be representative of a sample experienced with blockchain technology. Notably, the findings show that organisational strategy for blockchain, a roadmap for blockchain adoption, and a dedicated team to implement the system received the three lowest mean scores. This supports the findings of previous case study research that when scaling or implementing a blockchain system, organisational factors become increasingly prominent, as opposed to the barriers being technical (Biswas & Gupta, 2019; van Hoek, 2019). The interview data aimed to further explore these barriers, and potential solutions,

whilst furthering the research body and accounting for the differences in strategy between incumbent and start-up organisations. One major divergence with regard to scaling the system is that it is easier to scale the solution throughout the supply chain when you are an incumbent organisation with strong supply chain relationships. Meanwhile, start-ups can more readily scale the solutions in-house as they have the correct management support, but they cannot influence the supply chain to the same degree. Thus, there is a clear need for future research to account for the types of organisations which they are researching as the barriers and solutions vary greatly based on the history of the organisation and the relationships they have established with their supply chain partners.

Scalability is complex and transcends the boundaries of the TOE framework as it has technological, organisational, and environmental facets and can consequently be defined and investigated in a variety of different ways. Some scholars have focused on scalability as a technological property of blockchain technology (Biswas & Gupta, 2019; Clohessy et al., 2021; Duan et al., 2020; Hastig & Sodhi, 2020; Kamble et al., 2019; Kouhizadeh et al., 2021; Yadav et al., 2020; Van Hoek, 2019; Wong et al., 2020a; Zhao et al., 2019), whilst others have considered the operational scalability of implementing a progressively complex blockchain solution (Kamble et al., 2019; Surendra Yadav et al., 2020; Van Hoek, 2019; Zhao et al., 2019; Treiblmaier et al., 2021), and some have elected to incorporate environmental factors into scalability either in their definition, or in their underlying barriers (Biswas & Gupta, 2019; Kamble et al., 2019; Van Hoek, 2019; Treiblmaier et al., 2021). There is also a portion of the literature which focuses on extrapolating findings from the cryptocurrency literatures and applying it the blockchain in supply chain literature (Clohessy et al., 2020; Duan et al., 2020). The consequence of the lack of a universal definition and varying approaches is that the scalability literature is largely fragmented and that, whilst the term scalability is often present, it is often not the same phenomenon being studied. The implication of this for stakeholders is that it is difficult to understand trends between the literature. As a result, in this research scalability is differentiated into three interconnected sub-categories – (1) technological scalability, (2) operational scalability, and (3) supply chain scalability – that each represent the various underlying scalability challenges present in the literature (Table 2).

Table 2: Scalability definitions being applied in this research

Term	Definition
Scalability Barriers	A series of problems which can occur as a direct result of increasing the scope of the existing blockchain system. This accounts for technological barriers, operational barriers, and supply chain barriers.
Technological scalability	An intrinsic property of blockchain technology that determines how massive the system can be scaled whilst maintaining efficiencies; that is affected by factors such as block storage capacity, transaction speed, technological integration and interoperability, data collection and accuracy, and required computational power.
Operational scalability	An organisational factor that determines the ease that the business strategy, employee training, and operational processes can be redesigned to accommodate the full blockchain system.
Supply chain scalability	An environmental dimension of scalability which determines how the blockchain solution can be scaled beyond the implementing organisations company boundaries to the wider supply chain and network. This factor involves challenges associated with supplier onboarding, collaborative efforts, inter-organisational trust, and open-book data exchange between supply chain partners.

There is also a divergence between the literatures which include an expert sample, who have first-hand experience scaling blockchain systems (Biswas & Gupta, 2019; Treiblmaier et al., 2021; van Hoek, 2019), and those which use a sample which do not have first-hand experience implementing blockchain systems (Clohessy et al., 2020; Duan et al., 2020; Hastig & Sodhi, 2020; Kouhizadeh et al., 2021; Yadav et al., 2020; Zhao et al., 2019). In the research where those with first-hand experience were interviewed or surveyed, operational factors such as organisational readiness, and supply chain factors like onboarding suppliers to the blockchain system, become increasingly prominent (Biswas & Gupta, 2019; Treiblmaier et al., 2021; van Hoek, 2019). Conversely, research that either used cryptocurrency literature or a sample without first-hand experience implementing blockchain, found that technological scalability was a prominent barrier to blockchain adoption due to factors such as security issues, storage capacity, and processing speed (Clohessy et al., 2020; Duan et al., 2020; Hastig & Sodhi, 2020; Kouhizadeh et al., 2021; Yadav et al., 2020; Zhao et al., 2019). This could also be a product of (1) the type of data not being accounted for in the majority of survey research as it takes a more generalisable approach, but being mentioned in the more specific case research, as some evidence suggests data type and confidentiality can affect the prominence of some barriers (Kouhizadeh et al., 2021; Van Hoek, 2019), and/ or (2) the blockchain objective not being specified in the more generalisable survey research whilst being mentioned in the case research, as some research suggests the objective of the blockchain could affect the prominence of some barriers (Duan et al., 2020; van Hoek, 2019).

2.1.3. Blockchain integration

As can be evidenced in Table 1, integration barriers are one of the least well documented challenges facing blockchain deployments in the supply chain use case. Integration barriers refers to challenges associated with synching the blockchain solution with the technology stack. This may include ensuring the blockchain is interoperable with other blockchains, integrating the blockchain with the supporting technologies, or integrating the blockchain technology with the legacy systems. In their SEM study, Kamble et al. (2019) surveyed

supply chain experts with advanced degrees. As was explained in the previous section, their study included 'discomfort' as a studied variable. One of the measurement items for discomfort was concern that the blockchain service provider who is providing the technology and performing a technological integration of the blockchain platform into their supply chain, would be capable of taking advantage of their supply chain. As a result, they hypothesised that discomfort using blockchain technology will inhibit perceived ease of use and perceived usefulness respectively. However, they found that discomfort had no influence on perceived usefulness or ease of use. This led to them concluding that supply chain managers do not see "lack of control" regarding the integration process as an inhibitor to blockchain deployment (Kamble et al., 2019, p2025). Further, they suggest that this may be a consequence of the expertise of the studied sample as they all advanced degrees and had worked in supply chain management in some capacity. However, the participants did not need blockchain expertise. Despite this, this finding is limited because the measurement is phrased in a way which may be considered to place the behaviour of the service provider as the subject of the measurement. Through this interpretation, the measurement is not concerned with blockchain integration challenges, but with interorganisational distrust of bad actors.

Like Kamble et al. (2019), Wang et al. (2019) also conducted blockchain in supply chain research where the participants were supply chain experts as opposed to blockchain experts. However, the authors extend upon the research of Kamble et al. (2019) by accounting for blockchain integration as a factor in their research design. Wang et al., (2019) studied the perceptions of blockchain technology in the supply chain use case and categorised their findings into three categories – (1) benefits, (2) challenges, and (3) applications. Notably, the integration topic featured in each of the three sections. Interviewees E and H stated that integrating blockchain technology with IoT would be able to offer significant value to the organisations as IoT can collect real time data that can be stored on the blockchain "data reservoir" (Wang et al., 2019, p228). Similarly, other interviewees in the study explained how blockchain may offer value when integrated with additional technologies such as robotics and artificial intelligence. In terms of challenges, of the 14 interviewees, 9 of them discussed technological and network interoperability issues. However, only limited insight into integration can be achieved as the findings section does

not detail the specifics of these issues as it focuses on other challenges which occurred – despite the category being the third most prominent challenge. As a result, the blockchain interoperability issues cannot be discerned in terms of context or significance beyond the frequency with which the category they belong to was discussed. Lastly, several interviewees expressed how blockchain may have application in industries where it solves a business need. One example is in how one Interviewee (M) explained how blockchain would offer significant value in the logistics domain due to the value it can offer in streamlining the current systems into a singular system. The authors did note that the interviewees had a general distrust of blockchain technology and a lack of familiarity with it, as they were supply chain experts who had not been involved in blockchain projects in supply chains as that demographic was very small at the time of their data collection given the advent of the blockchain in supply chain use case was around 2015 (Vadgama & Tasca, 2021).

Building on the work of scholars such as Wang et al. (2019) and Kamble et al. (2019), van Hoek (2019) conducted a mixed methods study to understand barriers facing blockchain deployments in supply chains that included participants who had first-hand experience working with blockchain systems. The research is significant for several reasons. Leaning on other novel technology adoption in supply chains literatures, the authors elected to differentiate integration issues into 4 different categories – (1) lack of understanding of integrating blockchain with the business processes, (2) challenges integrating blockchain with existing technologies, (3) blockchain interoperability, and (4) database integration challenges. This accounts for limitations in preceding research by differentiating between different modes of integration, and permitting a greater level of insight into which integration challenges are considered an issue. Within the survey portion of their research, the chosen data collection and analysis methods permitted insight into the significance the sample placed on each item as an inhibitor. Notably, lack of understanding about integrating blockchain into existing processes was the most significant inhibitor of blockchain adoption within the 29 measured factors within their research. Challenges integrating blockchain was the 10th most significant challenge, blockchain interoperability was 16th, and database integration was the 24th least significant issue. This finding demonstrates the value in differentiating between different types of integration issue as integrating with the business processes was considerably more significant an issue than integrating blockchain with the

databases. Clohessy et al. (2020) conducted a systematic literature through the lens of the TOE theoretical framework where they also accounted for different types of integration challenges. However, they did not include as many types as in the van Hoek (2019) study. Notably, blockchain interoperability only appeared in 1 of the 31 reviewed studies. Showing that blockchain integration with other blockchains was considered even less of a challenge in the extant literature than in the van Hoek (2019) study. Van Hoek (2019) also included a case study where they explored the findings from the survey research in real supply chain use cases. This accounts for the limitations of the first part of their research in that the survey sample did not have blockchain expertise as a prerequisite. This also account for the need for research which provides a contextual understanding of integration issues in previous literatures (Kamble et al., 2019; Wang et al., 2019). The case studies were conducted on 3 cases where organisations were implementing blockchain technology and they used interview data to build an understanding of each case. However, in the 3 studied cases, integration issues were not found to be an issue. This contradicts the findings of the survey research and is an area where further research is needed to understand blockchain integration issues. This may have occurred due to the survey sample not being experienced with blockchain, or this may be a consequence of the cases not being scaled beyond a pilot. This is acknowledged by one of the interviewees as they explained how blockchain interoperability may become an issue as the project scales beyond a pilot and the blockchain has to interact with other blockchains.

In their survey research conducted on employees at Malaysian SMEs, Wong et al. (2020a) included complexity as a factor within their research. The included all technological challenges under the term complexity. They found that as the complexity of the deployment increases, intention to adopt blockchain decreases. This conflicts the findings from the prior research of Kamble et al. (2019) who concluded that supply chain managers do not seem deterred by discomfort in using blockchain as long as there is a sufficient value to be realised. Thus, this may be evidence of a lack of generalisability between Malaysia and India, or this could be a consequence of the stricter participation requirements in the Kamble et al. (2019) research pertaining to blockchain knowledge. Alternatively, this may be an indicator that in circumstances where resources are limited, complexity reduces the intention to adopt blockchain as they also found that complexity increases the cost of the adoption. This

could suggest that the theoretical frameworks which can account for resources, such as the resource-based view and/ or calculativeness, are an appropriate lens through which to study blockchain adoption.

Hastig & Sodhi (2020) conducted a Thematic Analysis of a literature review aiming to understand what critical success factors must be present in order for a blockchain deployment throughout a supply chain to be realised. This research was significant as it was the first paper to conduct research into critical success factors of a blockchain deployment as the extant literature at the time was heavily concerned with barriers to blockchain deployment. They identified 6 constructs which must be addressed for the deployment to be successful. Within their technology readiness construct, the authors included three different integration factors – (1) System integration, (2) cost of integration, and (3) legacy system integration. They concluded by stating that managers need to integrate blockchain technology into their legacy systems as a consequence of the large investment into the legacy systems over the previous years. This is consistent with established literatures that show novel technology implementation is influenced by the existing infrastructure (Collins et al., 1988). They also add that there is a need to reengineer business operations and strategy around the blockchain based system. However, this research is limited in that it was an analysis of secondary data. Future research should endeavour to understand the critical success factors through the collection of primary data. Their methodology also collected data which was within supply chain domains, and was not specific to blockchain technology. This should also be accounted for in subsequent case research that collects contextual data on real world blockchain in supply chain projects.

Like Hastig and Sodhi (2020) and Clohessy et al. (2020), Yadav et al. (2020) conducted a literature review study into blockchain adoption. They derived 10 constructs which were seen as barriers from the journal articles studied. Unlike similar previous studies (Clohessy et al., 2020; Hastig & Sodhi, 2020), their methodology permitted insight into how these variables are manifesting and from this they made actionable recommendations to management about how to have a successful blockchain deployment. They found complexity of blockchain system design as being one of the most significant barriers to blockchain adoption. This corroborates findings of Clohessy et al. (2020), Hastig and Sodhi (2020), Wong et al. (2020a), and the survey data of van Hoek (2019). However, it conflicts

the interview data of van Hoek (2019). Their data analysis extended this by differentiated the variables into categories according to their influence and reception to the other variables. Notably, complexity of blockchain system design was a 'driving' barrier. These constructs have a low dependence on other constructs but a high driving power in determining adoption. As a result, the authors concluded that addressing the complexity of the system design is of high importance and should be one of the barriers which is addressed first as this will alleviate other issues.

Unlike some other technological challenges organisations face when deploying blockchain technology, integration challenges are not well established in the extant literature; despite some research showing their significance. Firstly, in several quantitative blockchain studies, integration issues are not included within the study. This is attributed to integration issues being outside of the established scope of the research. However, as is the case with Kouhizadeh et al. (2021), this a consequence of integration issues not being frequently discussed in the extant literature. This can be explained by how the studied variables in their study being developed from their literature review of blockchain technology. In some studies, integration issues are included; however, the chosen data analysis methods do not permit insight into integration specifically as integration issues are a part of a larger grouping of codes (Kamble et al., 2019; Wong et al., 2020a). The research of van Hoek (2019) and Hastig and Sodhi (2020) developed the research on blockchain integration in a supply chain setting as they accounted for a limitation in previous research. They differentiated between different types of integration issues and as a result, in both cases they found that perceptions of the different integration dynamics were different. This shows that integration challenges cannot be understood as a collective, as they each manifest in different ways. Thus, future research needs to account for technological integration by recognising blockchain interoperability, blockchain integration with legacy systems, and blockchain integration with supporting technologies. Lastly, with integration challenges not being well documented in a supply chain setting, there is a need for future research to understand this factor through both a qualitative and quantitative lens. Moreover, case study or interview study research would be recommended as this can provide a deep contextual understanding of where integration challenges are occurring, why they are occurring, and how they can be mitigated (Yin, 2018). Currently, case-based research does

not provide sufficient insight into blockchain production-grade blockchain projects as the majority of case research and interview studies are studying proof-of-concept or pilot grade deployments, or capture the perceptions of a demographic with no first-hand blockchain experience (Treiblmaier et al., 2021; van Hoek, 2019; Wang et al., 2019). Thus, issues may arise when trying to scale the blockchain beyond a select limited group of supply chain members which are currently not evidenced within the academic literature.

2.1.4. Data collection and supply chain digitalisation

Data collection challenges are issues which have been documented in the literature on numerous occasions. This can be evidenced in the literature review studies of Duan et al., (2020) and Hastig & Sodhi (2020). In their research on blockchain in the agri-food sector, Duan et al. (2020) concluded that raw data manipulation is a significant challenge facing blockchain technology. They reason that this is an issue which the immutability feature of blockchain technology does not account for. Thus, just because the blockchain produces immutable data which may increases trust in the data, this does not mean that the initial data may have been incorrect. The scholars also note how when you use supporting technologies, such as IoT, there can be difficulties in ensuring that the data which is collected is accurate. They cite two papers which discuss how IoT sensors can be tampered with so that they provide falsified results which would be impossible to recognise just with blockchain immutability as a sole assurance method (Lin et al., 2017; Galvez et al., 2018); however, in both cases the cited papers did not document first-hand accounts of this issue. Likewise, Hastig & Sodhi (2020) also find data collection challenges to be a barrier to blockchain deployments as a consequence of their literature review. However, unlike Duan et al. (2020), they consider data collection challenges to be a supply chain issue as opposed to a technological issue. This is because from their literature review, they found data access was the issue which needed to be addressed. This is because they recognised a need to obtain access to the supply chain that Is necessary in order to collect data that is traditionally outside of the focal firm's organisational boundaries. This may involve accessing the physical supply chain in order to place data collection devices, through means

such as IoT, or there may be a data controller in the supply chain who is needed to provide the required data for the blockchain. In both cases, data accessibility is a challenge which must be addressed at a supply chain business-to-business level as opposed to being a technological issue.

Wong et al. (2020a) conducted survey research into blockchain adoption in supply chain management. In their study, complexity was a broad term which detailed difficulties associated with using and understanding the technology. As such, whilst not explicated, data collection issues highlighted in other studies, such as incorrect raw data (Duan et al., 2020) and data accessibility (Hastig & Sodhi, 2020), may be considered as part of the complexity construct within Wong et al. (2020a). They found that complexity was a significant barrier of blockchain adoption within the studied sample. This suggests that if the end users are struggling with using the system, then it is likely to system will never be fully implemented. However, with the broad use of the complexity construct, this does not necessarily mean that data collection issues specifically will cause lower rates of blockchain adoption. Unlike Wong et al., (2020a), van Hoek (2019) accounted for data quality as its own construct. In the survey part of the van Hoek (2019) mixed methods study, the author found that 'lack of data quality' was a challenge that the sample felt was of lower-middle importance of the options available. However, this was not also evidenced in the case study segment of the research. In Case 01, one participant stated that data integrity is an issue, especially as they are currently doing data entry manually. They do imply that the intention is for this data to be pulled from other sources in the future which would be expected to mitigate this issue somewhat by removing some opportunity for bad actor involvement. Alternatively, Case 02 found that the suppliers would resist the blockchain deployment if it involved them having to manually input data. Thus, in both cases, automation of data collection through supporting technologies was a barrier that had not yet been solved.

Like van Hoek (2019), Wang et al. (2019) also conducted an interview study which aimed to understand perceived benefits, expected disruptions, and challenges in scaling blockchain solutions throughout supply chains. However, this was achieved by interviewing supply chain experts with 'sufficient' blockchain understanding. The authors found empirical evidence for several data collection challenges. Firstly, they note how achieving data integrity and high data quality is difficult to achieve. This led to one interviewee stating that

private blockchains would prevail over public blockchains as the preferred medium for supply chain application. Secondly, they found that attaining access to the data of supply chain partners will be a challenge for some organisations. This shows empirical support for Hastig & Sodhi (2020) in acknowledging that data collection is often dependent on non-technological issues relating to negotiating access with supply chain partners. Lastly, the authors also state that with large amounts of data being collected, it may be a challenge to identify the significant data from the larger dataset. However, it is worth caveating that this is an issue which is not uniquely facing blockchain deployments in supply chains as the blockchain system itself only stores data, it does not necessarily require any additional data to be collected than what was being collected in the legacy systems.

Treiblmaier et al. (2021) also found very similar findings to van Hoek (2019) in their mixed methods study. In their survey with attendees at supply chain conferences, they found that lack of data quality was of mid importance relative to all the other variables investigated. It is worth noting that both of these samples were of a supply chain persuasion and not necessarily individuals with expertise in blockchain technology. Their interview study accounted for data issues in two ways. Firstly, data was considered at an intra-organisational level with their 'lack of tools' construct which accounts for limitations from a technological perspective in capturing data which is necessary for a successful blockchain project. This result showed that the participants felt this could be minimised through an outsourcing strategy rather than developing the solution in-house. They continue by differentiating between start-up and incumbent organisations. They state that developing a blockchain solution that integrates with the pre-existing legacy infrastructure should be less of a technological leap for incumbent organisations. Secondly, they included 'information disclosure policies' as a barrier at an interorganisational level. This extends of the work of Hastig and Sodhi (2020) and Wang et al. (2019) who each acknowledged data accessibility as an issue which must be addressed when collecting data form supply chain partners. They continue by suggesting establishing a governance structure for the supply chain members is an actionable method for incumbent organisations with good, long lasting relations with their suppliers. Whilst they also reason that start-ups need to work in trust building with their supply chain members before they can achieve this type of implementation. This in contrast with the case study research of Clohessy & Acton (2019). Within their interview

research on several cases, they reported on no instances where organisations mentioned data integrity or data quality concerns. This could be a consequence of the blockchain projects being more established within the Clohessy and Acton (2019) study than in the van Hoek (2019) study. This is supported by how none of the project in the van Hoek (2019) study had progressed beyond a pilot grade deployment. Alternatively, this may be explained by the resources available to the organisations in the Clohessy and Acton (2019) study as several of them organisations had several hundreds, and in some cases thousands, of employees, suggesting that they may be more resource laden than the cases in the van Hoek (2019) study.

Data collection issues are fairly well established in the extant literature in both a quantitative and qualitative context. Survey research that accounts for data quality or data integrity has demonstrate that this is a concern which is of relatively middling degree of importance relative to other challenges organisations face when deploying blockchain solutions throughout their supply chain (Treiblmaier et al., 2021; van Hoek, 2019). The interview studies extend upon this by contextualising how and why data collection issues may occur. Firstly, raw data manipulation is an issue whereby the data is manipulated, either intentionally or accidentally, prior to it being inputted onto the blockchain (Biswas & Gupta, 2019; Van Hoek, 2019). As was documented in the van Hoek (2019) cases, this can occur in instances where the data is entered manually onto the blockchain as there is opportunity for human error, and potentially fraudulent adjusting of the data. Secondly, data accessibility was also acknowledged as a barrier to accurate data collection. Lack of data accessibility is where an organisation whom are seeking to deploy the blockchain system throughout their supply chain, cannot collect the required data about products within their supply chain as a consequence of the desired data being outside their organisational barriers and as a result, access to the data is controlled by a separate legal entity (Hastig & Sodhi, 2020; Treiblmaier et al., 2021; Wang et al., 2019). In instances where the data is intended to be automated, this can prevent supporting technologies, such as IoT devices which capture the required data in real time, from being deployed, which prevents the data from being captured and fed onto the blockchain system. Alternatively, even in instances where the data collection would not be automated, this can prevent data from being shared by the supplier to the focal firm. This has been evidenced within the empirical

case study research of van Hoek (2019) as one of the involved supply chain members would not permit the focal firm access to any additional data if it included any increase in workload on behalf of the supplier for the system to be deployed. Whilst not being technological in nature, this does prevent technology from being able to function as intended. However, few studies have suggested actionable operations which may be able to alleviate these issues. One study which did make recommendations was Treiblmaier et al. (2021). The authors concluded that there is a need to differentiate actionable approaches according to whether the focal firm is an incumbent organisation or a start-up. This is because the incumbent can focus on leveraging existing resources and existing supplier relations whilst the start-up needs to build trusting relationships with a few close supply chain members. Lastly, Treiblmaier et al. (2021) also recommended that there is a need to establish governance structures and to codify these relationships into smart contracts as a means of alleviating challenges associated with access to raw data that were documented by other scholars (Hastig & Sodhi, 2020; Van Hoek, 2019; Wang et al., 2019). However, other in-depth case studies didn't report any issues concerning data collection or supply chain digitalisation (Clohessy & Acton, 2019). This may be attributed to the different stages of the blockchain projects and the resources divergences between the included cases (van Hoek, 2019). This resource-based view where resource laden organisations may be less impeded than smaller organisations or start-ups, specifically in terms of data quality and data access, may be supported by the findings of Treiblmaier et al. (2021) which empirically demonstrate a need to differentiate between larger and smaller organisations. However, further research would be needed which can account for differing levels of resources in order to understand if this theorem.

2.1.5. Energy and sustainability

There are a series of literature review studies which have found energy and sustainability to be an issue facing blockchain technology in a supply chain context. Zhao et al. (2019) found the most prominent issue was energy cost and technological scalability; whilst Hastig & Sodhi (2020) found that technology readiness, of which energy consumption was an input,

should be evaluated by managers in order to assess if the technology is at the required standard to realise the business objectives. Similarly, this is supported by the literature review and Delphi method study of Yadav et al. (2020) who also found that energy issues were a consequence of technological scalability. However, Zhao et al. (2019) only included supply chain traceability literatures whilst Hastig & Sodhi (2020) included several searches which included cryptocurrency terminology. Thus, neither study holistically looked at blockchain adoption in supply chains. Conversely, literature review studies such as Clohessy et al. (2020) only included literature on blockchain implementation and they found less than 15% of these papers mentioned energy issues related to technological scalability. Thus, this may be evidence that energy related issues are not prominent in the blockchain in supply chain literatures, which is further evidence for the need to differentiate between cryptocurrency literatures and blockchain in supply chain literatures.

Biswas & Gupta (2019) endeavoured to collect survey data which could be used to understand which barriers to blockchain adoption influence other barriers – allowing for industry to prioritise accounting for the causal barriers as these will mitigate the receiver barriers. From their literature review, they identified energy costs as being a prominent barrier to blockchain adoption in supply chains. However, like Hastig and Sodhi (2020), their literature review included cryptocurrency literatures, making insights into the supply chain use case limited. Despite this, the analysis of their survey data shows energy costs are a receiver barrier. Moreover, they find that the causal barriers scalability challenges, technology risks, and legislative uncertainty are the three causal barriers which influence the energy costs the most. Thus, the authors conclude that to address energy challenges, organisations should first invest in reducing the technology risk and dedicate resources to blockchain scalability. However, this is not necessarily the case as this finding is based on survey data collected from a sample of 20. As a result, the limited sample may not enable generalised understanding of the phenomena being studied. Further, it is unclear what level of familiarity the participants had with blockchain technology deployments. Despite this, the research does provide evidence that to address energy issues, technological scalability as it pertains to factors such as the protocol verification method, and the information throughput speed must be improved.

Whilst no directly concerned with blockchains energy issues, Nayal et al. (2021) conducted survey research to understand which factors influence blockchain adoption. Notably, they found that organisations who have sustainability focused practices are more likely to adopt blockchain technology than those who do not. This does suggest that more sustainability inclined organisations do not find blockchain technology to be in opposition to their green practices. Further, as the correlation is supported, this may even be evidence that blockchain technology is viewed as a net positive in terms of its sustainability cost by organisations with green practices. It is worth juxtaposing that the divergence between this research and earlier research with regards to energy costs, may be a consequence of the period of data collection as blockchain technology has had more time to mature and develop in 2021 than hit had previously (Treiblmaier et al., 2021). This is significant given the novelty of the technology. This may be supported in the case study research of van Hoek (2019) as case 02 within their study cited their motivation for deploying blockchain technology as being sustainability motivated. Further, the interviewees explained that the blockchain had allowed them to improve how energy is being used within their organisation as the purpose of the blockchain was to provide insights into energy usage.

Energy and sustainability issues are not prominently discussed within the literature. Further, the times they are discussed they are included as a consequence of an overreliance on cryptocurrency literatures being included within the study (Hastig & Sodhi, 2020; Yadav et al., 2020; Zhao et al., 2019). This is notable given that emergent studies on blockchain deployments within supply chains do not find energy concerns to be an issue, with it often not discussed within the article (Clohessy & Acton, 2019; Treiblmaier et al., 2021; Van Hoek, 2019). Further, some survey research shows conflicting evidence that energy issues are actually mitigated through the deployment of a blockchain solution, as opposed to energy and sustainability being a barrier facing blockchain technology (Nayal et al., 2021; Van Hoek, 2019). Despite this, more emergent research is needed to further investigate if this is a barrier to blockchain in a supply chain by allowing industry experts with first-hand experience in deploying blockchain solutions to guide the discussion organically without the topic being brought up by the interviewer.

2.2. Organisational context

2.2.1. Organisational readiness

In this study, organisational readiness is defined as the potential for an organisation to implement novel IT infrastructure according to their availability of resources (Weiner, 2009). As noted by Clohessy and Acton (2019), this generally considers human, financial, and infrastructure resources. However, as existing infrastructure is a technological consideration under the TOE framework, this section focuses on human resources and financial resources specifically. In their conceptual paper based on their review of blockchain literatures, Saberi et al. (2019) categorised barriers to blockchain adoption in sustainable supply chains through the lens of their TOE theoretical framework which is adapted to increase the specificity of the framework to the blockchain in supply chain use case. Within intra-organisational barriers, they differentiated between financial constraints and lack of knowledge and expertise as distinct constructs. This is significant as it is one of the early studies that acknowledges divergences in how these constructs occur and how they should be mitigated.

Clohessy et al. (2020) developed an integrative framework from a literature review which aims to explain the barriers to blockchain adoption through the lens of the TOE theoretical framework. From their literature review, Clohessy et al. (2020) found organisational readiness to be the second most frequently cited barrier to blockchain adoption in supply chains, and most frequently discussed organisational barrier, from the reviewed literary body. However, their method does not permit insight into the importance of each subconstruct, of human, financial, and technological resources, and as a result, the insights provided by this finding are limited. This limitation is accounted for in the literature review study of Yadav et al (2020) as, consistent with the proposed differentiating approach of Saberi et al. (2019), initial capital requirement was identified as a barrier from their literature review. They then, analysed each identified barrier in relation to each other to understand their interdependencies and influence over other included barriers, extending upon the research of Clohessy et al. (2020). They found that initial capital requirement was

a dependent barrier – meaning it is a construct which is influenced by other variables and has limited influence over other constructs. Further, this variable was the second most dependent variable within their study. Thus, to address the initial capital investment challenges, other issues must be mitigated first. This leads them to concluding that government regulation and agri-food stakeholder awareness are the two challenges which must be addressed first in order to lower the initial investment cost.

Building on the research of Saberi et al. (2019), Biswas & Gupta (2019) also differentiated between organisational readiness subconstructs as they conducted survey research into blockchain adoption barriers. In their study they accounted for 'poor economic behaviour' of the blockchain specifically. They found that poor economic behaviour of blockchain technology was a receiver barrier, meaning that it had limited influence over the other variables in the study, but was greatly influenced by the other variables in the study. More specifically, legislative challenges and technological scalability were the most impacting variables on the economic behaviour of blockchain. Thus, it would be expected that as these issues are addressed, the required financial resources for engaging in a blockchain project would decrease as the entry requirements for blockchain projects would lessen. This finding is concordant with Yadav et al. (2020) as it shows empirical evidence of financial barriers being dependent on governmental regulation.

Whilst Biswas & Gupta (2019) researched blockchain adoption barriers, Wong et al. (2020a) tried to understand what factors can influence and deter blockchain adoption in their survey research on Malaysian SMEs. The found that the cost associated with deploying blockchain was a consequence of the complexity of the blockchain which is being implemented and the relative advantage that the blockchain is trying to provide. Thus, this implies that the more ambitious the project, the more likely costs are expected to increase. They also predicted that cost would negatively impact the behavioural intention to adopt blockchain in supply chains. However, they found this to not be supported. Thus, cost does not seem to be a determining factor in predicting if an organisation will seek to establish a blockchain throughout their supply chain. These findings in conjunction may be explained by perceptions of the relative advantage and expected value that can be offered by the blockchain solution outweighs the concerns over costs within the demographic sampled.

Supporting the survey research of Wong et al. (2020a), Kouhizadeh et al. (2021) also found that financial constraints do influence the hesitation to blockchain adoption in sustainable supply chains. However, they find that this influence is of relatively low significance when compared to the other barriers in the study. They explain that this may be an indicator that blockchain technology is relatively inexpensive to adopt compared to other information systems. However, this finding should be caveated that the sample was relatively small for survey research as only 47 participants were involved in the study. Thus, this finding may not enable statistical generalisation. Accounting for this limitation in the work of Kouhizadeh et al. (2021), Nayal et al. (2021) conducted a similar survey study where they had over 300 respondents. In their study, the authors included internal and external conditions as a variable, trying to understand how this can impact adoption of blockchain technology in agri-food supply chains. They found that internal and external variables were the third most influential factors in determining if an organisation will adopt blockchain. However, it is worth noting that in their study, internal and external variables accounted for a very broad number of factors; most of which were not concerned with the definition of organisational readiness being applied in this research. Thus, the influence organisational readiness has on determining blockchain adoption, cannot be gaged from this study as it was outside of the scope of their research objectives; despite its inclusion as a subconstruct within a wider variable.

Involvement in the previously discussed literatures required supply chain experts, that may have some understanding of blockchain technology (Kouhizadeh et al., 2021; Nayal et al., 2021). Likewise, Wang et al. (2019) conducted an interview study to understand blockchain adoption barriers where the participation criteria required that the interviewees were supply chain experts with some 'familiarity' with blockchain. However, it is not clear if 'familiarity' is considered to be a stricter participation criterion than 'understanding'. In their study, the authors found costly implementation of blockchain technology to be a barrier to blockchain deployment. As was mentioned previously, participation required 'familiarity' with blockchain; however, it is not clear what this entails. This is significant as there is a substantial difference between knowing of blockchain, and overseeing a blockchain deployment within your organisation. Thus, due to the deliberately wide scope of possibilities enabled by the phrasing, it is assumed that at a minimum, some of the

participants had no experience working directly with blockchain technology. This is further supported by the infancy of this research as at the time of publication, few studies had managed to collect empirical qualitative data from individuals who had first-hand experience working on blockchains in a supply chain context (Clohessy & Acton, 2019; Van Hoek, 2019). This issue is compounded by how their presentation of the data, does not permit insight into the specific sub-constructs and which interviewees discussed them. This is limited because they elected to consolidate, financial issues, data privacy issues, legislative issues, and data security issues into a single construct. Thus, when they report that 10 of the interviewees discussed this construct as a barrier, no specific insight can be gained as to which sub-constructs they were discussing. Despite this, they do include some vignettes from the data set. One excerpt from an interview explained that blockchain deployments are harder to initiate in organisations where resources are not abundant. Thus, this implicates that blockchain adoption is resource dependent and that this barrier to blockchain deployment is contextual to the available financial resources of the funding firm(s).

Like van Hoek (2019), Clohessy and Acton (2019) conducted case study research to understand blockchain adoption in supply chains. They included organisations that had blockchain projects as well as organisations that didn't. Thus, their findings permit insight into differences between organisations that adopt blockchain and those that don't. Notably, one of their strongest findings, they found that 8 of the 20 involved cases, had sufficient organisational readiness with respect to their financial resources. Further, in all of these 8 organisations, a blockchain program had been implemented. They conclude that this is a consequence of organisations with a greater level of resources in terms of finances, IT infrastructure, and employee competence, allows for a greater degree of experimentation with novel technologies such as blockchain. This is consistent with findings looking at technology adoption in businesses more generally (Fichman, 2004). This is supported by how one of the interviewees explained that they had received 'substantial' financial resources for a blockchain project, despite acknowledging that there had been no evidence of the business use case been demonstrated in other organisations within their country at that point (Clohessy and Acton, 2019, p1479).

The survey data within the van Hoek (2019) study found that employee understanding was an extremely significant barrier to blockchain deployments. This was because of the 29 constructs which were included in their study, the sample considered seven different dimensions of understanding to be the seven most severe barriers to adoption. Thus, lack of understanding about costs, expected ROIs, business use case, technological limitations, and blockchain technology more generally were some of the issues which the sample felt were most prominent. Notably, the cost of blockchain was a barrier of mid-importance; however, lack of understanding about blockchain costs was the 3rd most prominent barrier. This permits several insights. Firstly, organisational readiness constructs need to be differentiated between as employee competencies and deployment costs are separate, albeit related, issues that are perceived differently. Secondly, at least in the studied sample, blockchain understanding and blockchain competencies are significantly more problematic for blockchain deployments than cost associated challenges. However, these findings are not consistent with the findings from the case study within their research. In all 3 of the involved cases, the costs associated with the blockchain project were discussed as being minimal. This may be a consequence of the projects being in pilot phase as opposed to being production grade deployments. Further, lack of understanding was also consistent between all 3 of the involved firms. Each organisation had used the pilot grade deployment of the blockchain as a learning opportunity to build blockchain competencies within their organisation. Thus, in terms of both financial and employee competence, there was a clear divergence between the case study findings and the survey data findings. This may be attributed to the participation requirements being different for involvement in each aspect of the research. Involvement in the case study required first-hand experience working directly with the deployment of a blockchain solution throughout a supply chain, whereas the survey research was collected from attendees at a supply chain conference. In light of these findings, future research is needed that accounts for financial challenges and understanding challenges separately, and that is conducted with participants with first-hand experience working on blockchain deployments in a supply chain context.

With regards lack of understanding, similar evidence may be observed in the research of Treiblmaier et al. (2021). Like van Hoek (2019), they collected survey data from respondents about barriers to blockchain adoption. They also found that various dimensions of lack of

understanding were deemed the most problematic by the sample. Alternatively, unlike van Hoek (2019), their survey research showed the cost of blockchain was the second least significant barrier in their research. Thus, further survey research is needed to better elucidate how financial resources can restrict or inhibit a blockchain project. Treiblmaier et al. (2021) explored the organisational readiness construct more specifically. They differentiated it into 7 subcategories which when together, should allow for an organisation to more readily implement a blockchain solution. They then asked participants to evaluate their own organisation against each of these constructs to provide insight into which organisational readiness constructs are the most lacking in their organisation. They found that the constructs which were orientated around acknowledging the importance of blockchain, such as upper management engagement with blockchain, were more present than constructs which referred to operational practices which could aid in the deployment, such as a roadmap. Thus, it can be concluded that of the involved sample, acknowledgment of blockchain technology and its potential is improving, whilst actual actions to deploy a blockchain solution are less common.

Organisational readiness has been included in several studies that aim to elucidate blockchain adoption in supply chains (Biswas & Gupta, 2019; Clohessy & Acton, 2019; Clohessy et al., 2020; Kouhizadeh et al., 2021; Nayal et al., 2021; Saberi et al., 2019; Yadav et al., 2020; Treiblmaier et al., 2021; Van Hoek, 2019; Wang et al., 2019; Wong et al., 2020a). However, in some studies it has been included as a singular construct (Clohessy & Acton, 2019; Clohessy et al., 2020; Nayal et al., 2021; Wang et al., 2019); whilst in others, the constructs which comprise organisational readiness have been researched separately (Biswas & Gupta, 2019; Kouhizadeh et al., 2021; Saberi et al., 2019; Yadav et al., 2020; Treiblmaier et al., 2021; Van Hoek, 2019; Wong et al., 2020). Several studies where the subconstructs are researched separately have shown that some of the subconstructs are more influential in determining what challenges will be encountered when deploying a blockchain in a supply chain. Notably, there is some evidence in survey research that lack of understanding of blockchain technology and blockchain competencies are a prominent issue facing blockchain deployments (Nayal et al., 2021; Treiblmaier et al., 2021; Van Hoek, 2019). Further, some case study research also shows that internal blockchain competencies are limited, and that these are being developed through the process of piloting blockchain

projects (Clohessy & Acton, 2019). There is also some evidence that blockchain competencies are improving; however, this has yet to translate into actionable plans to deploy a blockchain solution (Van Hoek, 2019). However, unlike internal blockchain competencies, challenges associated with financial challenges have less consensus in the extant research. Some studies have shown financial challenges to be one of the most prominent challenges facing blockchain deployments (Clohessy & Acton, 2019; Clohessy et al., 2020; Nayal et al., 2021; Wang et al., 2019); whilst others have shown financial challenges to be of mid-to-low level significance (Biswas & Gupta, 2019; Kouhizadeh et al., 2021; Yadav et al., 2020; Treiblmaier et al., 2021; Van Hoek, 2019; Wong et al., 2020a). However, the case study research has shown that financial challenges were not an issue facing the studied deployments. van Hoek (2019) found that none of their involved case studies had financial challenges associated with blockchain projects. Further, some interviewees with first-hand experience working on blockchain projects in a supply chain use case have explained that blockchain projects are inexpensive (Van Hoek, 2019). Likewise, Clohessy and Acton (2019) observed that in every case that had deployed blockchain, they were all organisations with significant disposable resources to dedicate to the project. Thus, financial challenges were not viewed as a challenge in that study. Due to the divergence in research regarding financial challenges specifically, further research is needed to understand where financial challenges occur within blockchain projects and why these occur. There is a need for the research to capture data from projects which have gone beyond pilot studies in order to explore if financial challenges become more prominent as the project increases in scale to production grade deployments.

2.2.2. Upper management support

This study applies the definition of upper management support that was put forth in the blockchain in supply chain study conducted by Wong et al. (2020a). As such, upper management support is defined as a twofold construct which includes: (1) the level of understanding that management have about the importance of the project, and (2) the level of involvement management have in supporting the project.

In adapting the TOE framework, Saberi et al. (2019) propose four types of barriers which face organisations when attempting to implement blockchain technology solutions in sustainable supply chain management. Within their organisational category, they included lack of management commitment and support as a barrier facing blockchain deployments in a supply chain setting. They explain that top management support is needed not only in the short term, but also to ensure there is a long-term commitment to the project. Justifying their position, they draw upon research which shows an inverse relationship between management support and resource allocation (Fawcett et al., 2006), showing that for the project to be sufficiently funded, management need to support the project and allocate the required resources to the project. Thus, they are recognising management support as part of the underlying causal mechanism that leads to insufficient resource allocation and then for the project to fail. Despite this, due to the conceptual nature of their research, they do not present their own empirical support for this proposition.

Similar findings can be observed within the literature review study of Hastig & Sodhi (2020). In their study, they found that leadership was a critical success factor needed for the deployment of blockchain solution throughout a supply chain. However, they differentiate this into three forms which they all stress are significant. Firstly, like Saberi et al. (2019), the authors stress the need for internal leadership. Likewise, they explain that strong internal leadership is intrinsically linked with resource allocation. However, they also state that there is a need for external leadership within the supply chain. Thus, extending upon Saberi et al. (2019), Hastig & Sodhi (2020) recognise that there is a need for champions of the project both within the focal firm and within some of the supply chain member organisations in order for the project to be supported to the required levels. However, they also include a third form of leadership – company leadership. They state how blockchain technology does not solely rely on a few individuals within the focal firm, but that the focal firm needs to act as a united front in the endeavour to deploy the solution with their partners. The authors cite the cases of Carrefour and Wal-Mart as examples of organisations that have been able to promote the technology throughout their entire supply chain because the entire company is backing and believing in the project.

The findings of Clohessy et al. (2020) also reaffirm the findings of Saberi et al. (2019) and Hastig and Sodhi (2020) with regards to management support improving resource allocation

required to adopt a novel technology. In their literature review study, they found that top management support was the second most frequently discussed challenge facing blockchain deployments in the extant literature. They also state that organisations where upper management support is present are more likely to be able to recoup the value of blockchain technology. Thus, whilst Saberi et al. (2019) stated that upper management support would improve resource allocation, Clohessy et al. (2020) found that upper management support would improve the value which can be elicited from the project. Thus, whilst manifesting in different ways, both studies acknowledge the underlying impact that upper management support can have on various factors. Lastly, they authors extend upon this by stating that upper management support is itself a consequence of the value which can be demonstrated at the proof-of-concept and pilot phases respectively. As a result, this implies that upper management support is not necessary at the earliest phases of the project development; however, the need for upper management support grows as you attempt to scale the project and that the value offered by the blockchain in the early phases of the deployment, can act as a catalyst to generate upper management support.

Kouhizadeh et al. (2021) conducted survey research with academics and industry practitioners. They aimed to understand the barriers to blockchain deployments in supply chains through the TOE theoretical framework. Their data analysis method enabled the insight into how the studied variables influenced each other; allowing for the most problematic barriers which influence others, to then be addressed first by practitioners. They found lack of management support to be the most prominent barrier in their research and that it had the largest influence over all of the other barriers that was studied. This supports the findings of the literature review studies of Clohessy et al. (2020) and Hastig and Sodhi (2020), as well as the propositions within the conceptual research of Saberi et al. (2019). A similar study was conducted by Nayal et al. (2021); however, they used a larger sample to enable statistical generalisation. Contrasting the Kouhizadeh et al. (2021) study, the researchers found that upper management support does not correlate with blockchain adoption in their study. This leads the authors to conclude, that this may be a consequence of upper management not understanding the relative advantages of adopting blockchain technology and thus, they do not intend to adopt blockchain technology. These findings can also be evidenced in the research of Wang et al. (2020). Their study was conducted through

the TOE theoretical framework. Like Nayal et al. (2020), they also found that upper management support does not correlate with blockchain adoption. Further, they also found that relative advantage supports upper management support. Like Nayal et al. (2020), this leads the authors to conclude that the return on investment that can be gained from blockchain adoption is the issue which must be addressed first.

Clohessy & Acton (2019) conducted case study research that involved several cases where blockchain was adopted and several cases where blockchain was not adopted. This permits insight into differences between organisations with blockchain projects and those without. Further, they also included organisations of varying size to allow for insight in how resources may aid and/ or inhibit blockchain adoption. In their study, which was conducted through the TOE theoretical framework, Clohessy & Acton (2019) found top management support to be an enabler of blockchain adoption. Notably, they also collected evidence showing that a lack of upper management support is a barrier to adoption, with one interviewee citing the lack of upper management support as the primary reason why no blockchain project is currently occurring. However, their reason was actually grounded in upper management seeing a lack of value from investing in blockchain technology. Thus, this suggests that upper management support is contingent on the expected return on investment that can be elicited from the project. This led to the researchers concluding that organisations should invest in training for upper management in order to improve their technological competencies. From their cross-case analysis, they found upper management support to be the second strongest variable in predicting if an organisation has adopted blockchain technology, behind organisational readiness.

Treiblmaier et al. (2021) identified lack of upper management support as a barrier within their literature review. Within their study, they included upper management support within organisational readiness. They then surveyed individuals to understand how the different subconstructs, within organisational readiness, each relate to each other. Notably, of the 7 included subconstructs, they found upper management to be the most prominent. This means that of the studied organisations, upper management support was the most prominent construct. Despite this, the authors note how all of the organisational readiness constructs were low in their prominence at the studied organisations. Alternatively, as a consequence of their interview research, the authors found management support to be a

solution to the barrier of changing organisational culture. Thus, if an organisation is struggling to get all of the employees onboard with the new ways of working, upper management may be well positioned to aid in this transition. They do also note how this is a solution which is better suited to incumbent organisations as opposed to start-ups.

Lack of upper management support is well established in the literature as a barrier to blockchain deployments (Kouhizadeh et al., 2021; Clohessy et al. 2020; Hastig and Sodhi, 2020; Saberi et al. 2019; Clohessy and Acton, 2019). The large sample survey research suggests that return on investment is something which is a prerequisite for upper management support (Wong et al., 2020a; Nayal et al., 2021). This has also been evidenced in one qualitative study (Clohessy and Acton, 2019). However, some research has shown that upper management support can increase the value that can be gained from the use of a blockchain system (Clohessy et al. 2020). As well as being discussed as a barrier, upper management support has also been evidenced as a means of mitigating other challenges facing blockchain deployments (Treiblmaier et al. (2021). There are two main explanations for this documented within the blockchain adoption literature: (1) Upper management support improves resource availability (Hastig and Sodhi, 2020; Saberi et al. 2019), and (2) some evidence suggests upper management support improves the capabilities of an organisation for process reengineering (Treiblmaier et al., 2021).

2.2.3. Return on investment

This research applies a broad definition of return on investment that is derived from one of the interviewees within the (Malik et al. (2022) study on the antecedents of blockchain technology. Whilst the authors do not focus on the blockchain adoption process, one interviewee notes how often organisations do not see the “real benefits” (Malik et al., 2022, p8) of blockchain technology if they focus on the financial aspects of blockchain technology. Thus, this study views any form of net positive value that is elicited from the blockchain system as being a return on investment, as this acknowledges that blockchain can offer value in means which are not pecuniary.

The early research of Francisco & Swanson (2018) combined the Unified Theory for Technology Adoption (UTAUT) with the blockchain adoption literature to develop a set of hypotheses that can be a foundation for future research. One of the four sub-constructs of the UTAUT is performance expectancy and as a result, the authors propose that the expected value which is provided by the blockchain can positively influence behavioural intention to deploy a blockchain system throughout the supply chain. One notable contribution is how the scholars approach the trust construct. In the conceptual model, trust is differentiated into two forms – (1) technology trust, and (2) inter-organisational trust. They then also hypothesised that technological trust and inter-organisational trust each moderate the relationship between performance expectancy and behavioural intention to adopt blockchain technology.

From their Thematic Analysis of their literature review, Hastig and Sodhi (2020) identified 6 critical success factors, with 15 subconstructs, that need to be present for a successful deployment of a traceability blockchain throughout a supply chain. Notably, they do not include any category or sub-construct which details a need for blockchain technology to be providing a sufficient value as an output of their research. However, they do separately identify a series of business requirements which the blockchain needs to service. The decision to address the business need separately from the other critical success factors may imply that the authors believe that the need for blockchain technology to create value supersedes all of the other critical success factors accounted for within their research. They conclude by stating that blockchain must provide value in one or more of these business needs, but that the implementation itself is then constrained by the identified critical success factors. These findings in conjunction imply that the business need must be identified prior to the blockchain deployment. Thus, organisations must have a clear understanding of the value which will be offered, in terms of the 6 identified constructs presented in Table 3, before they begin to deploy the blockchain.

Table 3: Types of business need that a blockchain can be used to addressed, adapted from Hastig and Sodhi (2020)

Type of return on investment
Meeting stakeholder needs
Curbing illicit business practices
Improving sustainability performance
Increasing operational efficiencies
Enhancing supply chain management
Sensing market forces and trends

In their literature review on blockchain adoption, Clohessy et al. (2020) explain that the majority of academic research into blockchain adoption as of 2020, was "primarily anecdotal" with few studies documenting actual use cases of blockchain deployments (Clohessy et al., 2020, p509). As a result, the perceived benefits of blockchain technology are not well established in the empirical literary body. Despite this, some research has shown that blockchain needs to provide a return on investment for the deployment firm for it to be adopted. One such study was conducted by Queiroz & Wamba (2019). In their survey research into blockchain adoption the authors collected data from India and the USA across various industries. They found that performance expectancy of blockchain technology positively supports behavioural intention to adopt blockchain in both India and the USA. Thus, they conclude that blockchain technology would need to offer a tangible benefit for it to be considered for adoption. This finding was extended in the case study research of Clohessy & Acton (2019). The authors conducted multiple case study research to understand blockchain adoption. They found that upper management support was one of the most significant determinants of blockchain adoption. However, one interviewee discussed how upper management support was contingent on upper management seeing the value which blockchain technology could offer to their organisation. As a result, the authors explained that expected return on investment may be determine if upper management will support the project. Thus, they expressed a need for investment in training for upper management so that they can better evaluate the value which may be elicited from a blockchain project.

A similar study was conducted from a quantitative perspective. Wong et al., (2020a) aimed to understand the determinants of blockchain adoption in supply chains. To do this they collected survey data from 194 SMEs in Malaysia and proposed questions which were derived from the TOE theoretical framework. In their study they included Relative advantage as a construct. They proposed that relative advantage would positively impact (1) behavioural intention to adopt blockchain, (2) upper management support, and (3) costs. Significantly, all three hypotheses were supported. This finding provides quantitative evidence for upper management support being predicated on the value which can be offered by blockchain technology which was found in the case study research of Clohessy and Acton (2019).

One limitation of the literature body on blockchain adoption is that a significant amount of the publications on blockchain adoption in a supply chain setting are literature reviews that include cryptocurrency literature as well as relevant supply chain literature (Biswas & Gupta, 2019). Despite this, some studies do present empirical findings discussing return on investment in the supply chain use case. Nayal et al. (2021) accounted for performance expectancy in their research into the impact blockchain technology can have on sustainable supply chain practices in the agricultural sector. They proposed that performance expectancy would be positively related to behavioural intention to adopt blockchain. However, they found that this was not supported. Thus, within the studied sample, organisations were engaging with blockchain technology without the potential return on investment being the driving force. This conflicts with prior research that has shown performance expectancy is a driver of blockchain adoption (Hastig and Sodhi, 2020; Wong et al. 2020a; Wang et al. 2019; Queiroz and Wamba, 2019).

Like Clohessy & Acton (2019), Wang et al. (2019) conducted used interviews to understand the value which blockchain technology can offer to supply chains. The authors achieved this through a series of interviews with supply chain experts who had varying levels of IT expertise. However, blockchain specific competencies were not required for inclusion. Several interviewees stated that the business challenge could be solved with ‘traditional databases and information systems’ (Wang et al., 2019, p231). Thus, this acknowledges that there is a need for blockchain technology to provide new means of making value for it to be a worthwhile investment. This implies that in scenarios where blockchain technology offers

the same, or less, value than a legacy system, blockchain technology will not be considered as a suitable alternative. This finding is discordant with the research of Nayal et al. (2021) who found that organisations would engage with blockchain even when there was no performance expectancy that the blockchain system would add value. The research of Wang et al. (2019) suggests that there is additional underlying reasons why blockchain technology would not be adopted in this scenario.

Van Hoek (2019) conducted a mixed methods study. They collected survey data from attendees at a supply chain conference to understand their perceptions of blockchain technology and its application in their businesses. Notably, extending upon the findings of scholars who found return on investment to be a driver of blockchain adoption (Hastig and Sodhi, 2020; Wong et al. 2020a; Wang et al. 2019; Queiroz and Wamba, 2019), uncertainty about return on investment was the barrier that the participants found to be the fourth most significant. This is significant as this finding shows the average supply chain professionals' opinion about blockchain technology, and it demonstrates that there is a lack of understanding about what the value is that blockchain can add for their organisation. However, this finding contradicts their case study research. In their case study research, the authors found that of the three studied firms, each had an expectation of the value the project would add. Interestingly, none of these expectations were directly concerned with reducing costs. One organisation wanted to increase the speed products move through the supply chain by reducing administrative burden; the second organisation aimed for blockchain to improve their sustainability; whilst the last wanted to improve safety by having a more transparent supply chain. The second case is especially interesting as they explained how blockchain was a part of their 'interest in learning and experimenting with technology as part of larger supply chain digitalisation ambitions' (van Hoek, 2019, p844). Thus, this may be interpreted as them not being concerned with the value offered by blockchain specifically, but more interested in engaging with a variety of technologies in an attempt to be innovative and be well positioned to capture value related to an array of technologies, as opposed to being concerned with blockchain because they understand the value it may add. This supports the statements of an interviewee in the Malik et al. (2022) study as they noted that blockchain can offer value outside of financial returns. However,

whilst all of the firms had an expectation of value in the van Hoek (2019) research, they did not discuss expected return on investment as a challenge to establish.

Supporting the quantitative findings of van Hoek (2019), the survey segment of the mixed methods research of Treiblmaier et al. (2021) also showed 'lack of understanding about the potential benefits of blockchain' was the second most significant barrier to blockchain adoption of the studied constructs. However, it should be considered that both sets of quantitative data were collected from a non-expert sample with working with blockchain. The interview data collected by Treiblmaier et al. (2021) found that there is a need to communicate the value of blockchain technology with the wider supply chain. Thus, this views the return on investment as being an interorganisational issue, as opposed to being an intra-organisational issue. This also signifies the importance of having supply chain members believe that the project can create a communal value that can be realised by each supply chain member. This finding provides empirical evidence supporting Hastig and Sodhi (2020) in explaining that the blockchain system needs to meet the needs of supply chain partners. This is significant as the majority of empirical research has either expressed how perceived value is a driver of blockchain, or that establishing the value can be a challenge, but all of these view value creation as being focal firm centric. Thus, future research needs to account for interorganisational value creation.

As is acknowledged by Clohessy et al. (2020), blockchain technology research is still in a state of relative infancy and as a result, some aspects of blockchain adoption research are less well understood than others. Further, this is reflected in the dearth of qualitative case study research that investigates return on investment challenges (Clohessy et al., 2020). Some early survey research evidenced that there is a need for blockchain to provide a return on investment for the focal firm seeking to deploy and fund the blockchain (Queiroz & Wamba, 2019; van Hoek, 2019). However, some subsequent research has extended upon this finding. Wang et al. (2019) found that the value creation afforded by blockchain needs to be disruptive in nature in order for it to provide new value that can sufficiently differentiate blockchain technology from legacy systems. Hastig & Sodhi (2020) identified 6 different types of value that can be created in additional to financial returns. Notably, one of these types of value was acknowledging the need to create a communal value from the blockchain system, as opposed to the deployment lead centric value creation discussed in

previous survey research. This was also evidenced in the case study research of Treiblmaier et al. (2021) as they found a need to have a supply chain centric value creation in order to be able to effectively communicate the value of the blockchain to supply chain members. Interestingly, some survey research has shown that performance expectancy of the blockchain does not correlate with behavioural intention to adopt blockchain Nayal et al. (2021); which may be an indication of blockchain involvement for other motivations. Quantitative and qualitative research has also provided evidence that blockchain value creation can have appositive impact on upper management support, which as discussed in the previous chapter may increase resource availability and process reengineering capabilities (Wong et al. 2020a; Clohessy and Acton, 2019). Several studies have also provided evidence that the identification of the value from blockchain technology should be established prior to engagement with the blockchain project (Hastig & Sodhi, 2020; Van Hoek, 2019). Lastly, some early conceptual research has hypothesised that interorganisational trust and trust in technology each impact the relationship between performance expectancy and behavioural intention to adopt blockchain (Francisco & Swanson, 2018); however, subsequent empirical research is needed to better test and understand how trust constructs can influence blockchain adoption.

2.3. External context

2.3.1. Legislation and policy

In their conceptual paper, Saberi et al. (2019) apply the TOE theoretical framework to develop a set of barriers organisations will face when deploying a blockchain solution throughout a supply chain. Drawing on wider literature, the authors identify governmental regulations as a challenge facing blockchain technology in a supply chain context. They state that this is in part a consequence of governmental policy being a biproduct of attitudes towards cryptocurrency. Likewise, as noted by Biswas & Gupta (2019), this influence of cryptocurrency in academic research has meant that blockchain technology in a supply

chain use case is less studied. Several scholars have conducted literature review studies which had findings related to governmental policy in the context of blockchain adoption. Biswas and Gupta (2019) identified a series of causal and receiver barriers from their literature review. Regulatory risks were found to be a causal barrier of blockchain deployments and were discussed as one of the main issues discouraging organisations from committing to invest in blockchain. However, they do not state any managerial implications for this issue, presumably recognising it as an external barrier which is difficult for any single organisation to mitigate. Zhao et al. (2020) conducted a systematic literature review where they identified and categorised the challenges currently facing blockchain technology in the agri-food supply chain, and expressed how these challenges need to be overcome to increase adoption. They found regulation issues to be one of the six most prominent issues to be overcome. Their recommendations to alleviate this were government focused as they called for a government setup public blockchain infrastructure as well as designing a corresponding sector specific regulatory framework for blockchain adoption. However, as noted by Duan et al. (2020) in their literature review, there have been cases of governments being corrupted by bribes relating to blockchain technology, which limits trust in government. Similar, findings were made by Hastig and Sodhi (2020) and Clohessy et al. (2020) who each included legislative frameworks as being an inhibitor for blockchain adoption due to the complexity of operating a blockchain in several jurisdictions with conflicting legal requirements. Yadav et al. (2020) found regulatory uncertainty to be one of the primary driving barriers to blockchain adoption. The authors reasoned that this is a consequence of incidents such as the banning of cryptocurrencies in 2013 in India, as well as the increased complexity that comes with operating in several countries in order to remain compliant with legislation such as the Prevention of Money Laundering Act, 2002. Like several other scholars, they call for a revision of some legislative policies to better account for blockchain technology.

One of the most comprehensive studies on the determinants of blockchain technology in the public sector was conducted by Reddick et al. (2019). This was not an industry or use-case specific research and instead took a macro level perspective of public sector blockchain projects generally. Whilst not specific to supply chain application, and whilst not being conducted in the private sector, the authors noted some interesting results which may add

value to the private sector literature on blockchain adoption in supply chains. They collected data from a variety of reputable indexes and conducted logistics regression to understand how environment factors such as government effectiveness, government corruption control, political stability, democratic participation, and government effectiveness will affect blockchain adoption. The authors found that countries with a high degree of cyber-security are much more likely to have a blockchain project. This could show that existing attitudes toward security is in fact a determinant of blockchain adoption. Likewise, the authors found more effective governments are more likely to adopt blockchain solutions. One of the most interesting results is that as a countries political stability increases, their likeliness to adopt blockchain decreases. This could be an indication that where there is greater risk, blockchain adoption is viewed as a potential solution. It is worth noting that the countries with the highest political stability, also had blockchain programmes. This could be an indicator of a 'U' relationship between these variables but further research would be needed to verify this. Finally, countries with higher democratic participation was not a determinant of blockchain adoption. This finding could show that external pressures of the public are not as impactful in the public sector at influencing adoption. Whilst this research was conducted in the public sector rather than the private sector, there is another caveat in that the data input for the research was not specific to supply chain uses of blockchain. As a result, if the different uses of blockchain have varied relationships with the independent variables being studied, then the results will be less accurate to any specific use type.

Wong et al. (2020a) and Wong et al. (2020b) conducted survey research in Malaysia to understand what causes organisations to action a blockchain deployment. In Wong et al. (2020a), regulatory support did not support behavioural intention to adopt blockchain. They authors reason that this is a consequence of Malaysia being the study location as Malaysia has only a few initiatives which promote blockchain technology, and that the majority of these initiatives haven't been implemented. Alternatively, Wong et al. (2020b) found that regulatory support had a mediating impact on facilitating conditions but not on technology readiness. As a consequence of this, the authors reasoned that there is a need for regulatory guidance that couples blockchain application and data protection regulation so that there is more clarity and guidance for organisations looking at blockchain technology as a solution for their business need.

In their survey study, Kouhizadeh et al. (2021) found lack of governmental policies to be a significant barrier to blockchain adoption. However, like several other authors their recommendations are directed to the governments as opposed to the focal firm. Thus, this implies that governmental issues are difficult for an organisation to address. As a consequence of their literature review, the Nayal et al. (2021) posited that regulatory support would positively influence behavioural intention to adopt blockchain. In their survey research, they found regulatory support was the 5th most significant variable influencing blockchain adoption. The authors reason that this is because as regulation supports blockchain, this increases the trust organisations have in blockchain. Saurabeh and Dey (2021) conducted survey research into blockchain adoption within the grape industry. The authors called for policy makers to provide guidelines and a set of standards which can be used to ensure legitimate practices when operating with a blockchain system.

Clohessy & Acton (2019) conducted an interview study with participants from some organisations which have blockchain projects and others which do not, in order to understand what causes an organisation to invest in blockchain technology. The authors found that evidence that there may be a lack of awareness of blockchain technology with one interviewee stating “most governmental officials are not even aware of blockchain and that is disappointing”, when talking about the lack of legislative incentive for blockchain in Ireland (Clohessy and Acton, 2019, p1479). This was also cited as being the reason an employee at a smaller organisation gave for his company’s reluctance to adopt blockchain as it was not a technology that had been endorsed by the Irish government.

Oguntegbe et al. (2022) discuss issues of government regulation being dissimilar in different countries. They reason that this may be exacerbated when operating in countries where cryptocurrencies have been made illegal, as blockchain and cryptocurrency are very interlinked in how they are perceived. Whilst their study did not focus on government and legislation in blockchain-supported supply chains, Treiblmaier et al. (2021) did conclude by acknowledging that the regulatory environment surrounding enterprise blockchain is advancing at a fast rate. Thus, any study only provides a ‘snapshot’ into enterprise blockchain and the external environment (Treiblmaier et al., 2021, p15). As a result, there is a need for continued revaluation of the role of government in relation to enterprise blockchain deployments.

Challenges surrounding governmental policies in the context of blockchain are some of the most well established in the literary body in terms of the frequency they are mentioned. However, it is important to consider that legislative challenges are fast moving and thus, studies generally present a snap shot of the legislative context at that time (Treiblmaier et al. 2021). Despite this, the empirical research shows that the specific challenges within governmental policy can manifest in a variety of ways. Some researchers have found that when a blockchain system is operating in a transnational supply chain, then the complexity of the required blockchain solution will increase as it needs to be designed to account for country specific laws for every country where the blockchain is in operation (Hastig & Sodhi, 2020; Oguntegbe et al., 2022). By extension, the solution also needs to be updated in accordance with the changing of any laws to remain compliant and as a result, will require greater monitoring of international legislation post deployment. This is indirectly supported by the research of Reddick et al. (2019) who found evidence that constructs such as political stability, government effectiveness, and democratic participation can all influence if a country will be supporting of blockchain technology. Research has also shown that legislation can be a deterrent to blockchain adoption and has been cited as a reason why organisations currently have no blockchain program (Clohessy & Acton, 2019; Nayal et al., 2021; Wang et al., 2019; Wong et al., 2020a). One way this occurs is that when a government has not endorsed blockchain technology, there is less trust in that technology by the constituents of that country (Nayal et al., 2021). Alternatively, in countries where governments are viewed as corrupt, there may be hesitation to adopt blockchain if they support blockchain (Duan et al., 2021). Despite the prominence of these challenges, solutions and attempts to mitigate these practices are few. This may be explained by how the solutions which are pitched are targeted at the legislative bodies themselves as it is an external issue which the focal firm has little control over (Kouhizadeh et al., 2021; Zhao et al., 2019). This can be evidenced in how a large quantity of the reviewed studies expressed that governments and legislative bodies should produce a set of standards and guidelines for enterprise blockchain adoption that can be used to aid in deployments (Saberi et al., 2019; Saurabh & Dey, 2021; Yadav et al., 2020; Wong et al., 2020b). Alternatively, some studies have reasoned that governments should create legislation which incentivises blockchain adoption as a means of endorsing the technology (Clohessy & Acton, 2019; Wang et al., 2019).

2.3.2. Collaboration, coordination, and governance

This literature review considers collaboration challenges as a broad category. Thus, themes within the literature pertaining to interorganisational trust, interorganisational relationships, cultural challenges, and onboarding supply chain members to the blockchain are all discussed within this theme. This is because collaboration challenges are viewed as the observable outcome, that may have several different, sometimes related, reasons explaining why they occur. In their early conceptual paper, Saberi et al. (2019) categorised barriers to blockchain adoption according to a modified version of the TOE framework. Within their eternal barrier's category, the authors included 'lack of external stakeholder involvement' as a barrier. However, they do not outline their rationale for including this as a barrier. The authors continue by making propositions that they call for future research to understand. They state that there is a need for research to understand collaborative governance structures that can be implemented when collaborating on a blockchain project with supply chain members.

Clohessy and Acton (2019) conducted an interview study where they compared cases of organisations who have adopted blockchain and organisations with no blockchain project in order to understand the factors that influence blockchain adoption. Notably, they found several interviewees discussed challenges in onboarding their supply chain members to the network. One interviewee found that their supply chain members failed to see the value blockchain would add for them. Alternatively, a different interviewee explained that their supply chain members hadn't allowed the blockchain to be deployed within their firm as the system was not compatible with their IT strategies; despite acknowledging that the blockchain offers value to their organisation. These findings show evidence where supply chain members need to realise value from the blockchain project, but that this may still not be a great enough factor to influence their decision as other factors such as their own strategies, may inhibit adoption.

In the interview study of Wang et al. (2019), one of the interviewees stated that blockchain can make onboarding and collaboration easier with supply chain members where there is a lack of trust established in the relationship. This conflicts Clohessy and Acton (2019) as they

found that even in trusting relationships where value is offered to the supply chain member, onboarding may still be problematic. Wang et al. (2019) also state that there is a need for organisations to establish a governance model that is compatible with the supply chain. Queiroz & Wamba (2019) conducted survey research in India and the USA to understand which variables impact blockchain adoption. The researchers found that trust in supply chain members had no impact on behavioural intention to adopt blockchain. However, they found that trust in supply chain members had a positive impact on behavioural expectation blockchain would be adopted in India specifically; whilst this was not supported in the USA. Thus, this research shows that there is a need to understand how cultural dynamics may influence the importance of factors such as trust between supply chain members. One of the case studies in the van Hoek (2019) study cited how privacy concerns with upstream suppliers ran counter to the objective of the blockchain as the system aimed to improve transparency. Despite this, all of the cases mention they are working with a small subset of suppliers at the pilot stage of deployment and none of them considered collaborative challenges as a significant issue. The governance structures which were being applied by the case organisations were not disclosed, and thus no insight into governance structures can be discerned.

In their survey research into blockchain adoption, Wamba et al. (2020) found that pressures from trading partners has a positive impact on blockchain adoption in both India and the USA. However, the authors do note how this may be characteristic based whereby India and the USA share a key characteristic that means trading partner pressure influences adoption. Thus, there is a need for research that explores trading partner pressure in different countries.

In 2020, a series of literature review studies were published on blockchain adoption in supply chains. In their literature review study, Hastig & Sodhi (2020) identified critical success factors which need to be present to increase the likelihood of a successful blockchain deployment throughout a supply chain. The researchers identified collaboration as one of the 6 constructs that must be present. They then differentiated collaboration into 3 subconstructs – (1) goal alignment, (2) partnership trust, and (3) stakeholder buy-in. The authors explain that when deploying a traceability focused blockchain system, upstream supplier buy-in to the project is critical to the deployment. Thus, alignment of goals

between supply chain partners and trust between supply chain members and focal firm is paramount to the deployment. This is an especially prominent issue when the data which is being shared can threaten, or is perceived it may threaten, a supply chain members competitive advantage or if the data would reveal information the supply chain member wishes to remain confidential. These findings all imply that there is a need to differentiate between (1) the type of data which is being collected with regards to confidentiality, (2) the objective of the blockchain system, and (3) the level or type of trust between the deployment lead and supply chain members; as these issues form the underlying causal mechanisms which influence the observed collaboration issues. The authors also note how deployment leads need to negotiate with the supply chain members about what specific data is needed and how this will be collected. In their literature review study, Yadav et al. (2020) identified 10 different barriers to blockchain adoption, and conducted analysis to identify the influences each of these barriers have on each other to identify which constructs were driving variables, and which were dependent. They found that lack of trust between agri-food supply chain members was the construct with the second greatest influence over other variables within the entire study. Notably, the construct had a high level of influence over all of the dependent constructs, meaning that trust issues between supply chain members can manifest in a multitude of ways. The findings also placed onboarding supply chain partners as a driving construct. Thus, both of these constructs must be addressed first in order to mitigate other issues which may occur in deployment. Duan et al. (2020) conducted a literature review study into blockchain adoption. They found that encouraging supply chain members to join the blockchain network was an issue in the extant literature. They note how this can become an issue due to differences in infrastructure sophistication, funding issues, and complexity to use the blockchain system.

Kouhizadeh et al. (2021) conducted survey research to understand blockchain technology adoption where there is a sustainability objective. The academics within their study suggested that cultural differences between deployment lead and supply chain members is an underlying causal mechanism which can impact all other external supply chain challenges in the study. Alternatively, both academics and practitioners in the study viewed collaboration challenges as a significant issue when deploying a blockchain solution. In both samples, they found collaboration challenges impacted information disclosure policies and

challenges in integrating operations with the blockchain system. Thus, in circumstances where a deployment lead has a poor relationship with a supply chain member, this result would predict a greater likelihood of failure to deploy the blockchain solution specifically due to data disclosure challenges and collaborative process reengineering. Treiblmaier et al. (2021) conducted a mixed methods study to understand barriers to blockchain adoption. In the survey portion of their mixed methods study, cultural and collaboration issues were each identified from their literature review and included as constructs within their survey research. The respondents rated the significance of each factor as a barrier to blockchain deployment. Collaboration challenges and cultural challenges were each regarded as being of lower importance relative to the other barriers within the study. These findings were further emphasised in their interview study as well. The authors reason that collaboration challenges can be mitigated through the creation of value for supply chain partners and through the inclusion of incentive mechanisms within the contracts. They also state that cultural challenges may be mitigated through the establishment of trusting relationships with supply chain members, whilst also having a clear outline of roles and responsibilities for engagement in the network.

Through SEM, Nayal et al. (2021) found that internal and external environment conditions have a positive impact on blockchain adoption. However, this construct is very broad as it includes subconstructs such as resources, trust in blockchain technology, cultural challenges as well as many others. Thus, it is not possible to understand which of these factors influence the outcome. Further, many of these subconstructs are considered within different categories of the TOE theoretical framework, and as a result, some of these variables were technologically or organisationally focused.

Whilst collaboration challenges are well documented in the extant literature relative to other constructs featured in blockchain adoption research, they are extremely nuanced, with a limited degree of consensus, and a large amount of complexity. The early conceptual paper of Saberi et al. (2019) identified onboarding supply chain members to the blockchain network as a potential issue deployment leads would face when seeking to deploy a blockchain solution throughout their supply chain. They also reason that governance structures need to be understood in terms of how deployment leads and supply chain members engage with the blockchain network. Thus, there is a need for research which can

permit understanding of how different governance structures may impact the deployment of blockchain technology. However, few studies have explored governance structures in the context of blockchain deployments throughout a supply chain.

As was highlighted in the literature review studies, onboarding suppliers to the blockchain network has been evidenced as a significant issue for deployment leads (Duan et al., 2020; Hastig & Sodhi, 2020; Yadav et al., 2020). Duan et al. (2020) found that this can be a consequence of low level of technological sophistication at the supply chain member organisation. Alternatively, some interview research has shown that onboarding supply chain members can be inhibited if the technological strategy of the supply chain member does not include blockchain (Clohessy & Acton, 2019). Thus, even in instances where technological sophistication is high, the overarching IT strategy may still be in conflict with a blockchain project. Additionally, some studies have shown factors such as funding agreements, complexity of working with blockchain, goal alignment, stakeholder buy-in, and lack of trust are all reasons why supply chain members may not be onboarded to the network (Duan et al., 2020; Hastig & Sodhi, 2020). Thus, there are many points of failure where issues may arise that may result in an organisation being resistant to joining the blockchain network. This may explain why Kouhizadeh et al. (2021) found collaboration challenges to be some of the strongest driving variables of other barriers within their study. Thus, these challenges should be addressed early in order to alleviate the impact of other barriers such as data disclosure challenges and collaborative process reengineering. Despite this, some research has shown collaboration challenges to be relatively insignificant comparatively to other studied variables (Treiblmaier et al., 2021). This can also be evidenced in the case study research of van Hoek (2019) who found that none of the studied cases were experienced issues in onboarding supply chain members within the smaller scale projects they were working on. This may be evidence that working with a preidentified small subset of suppliers may be a means of expanding the blockchain project, with fewer issues. Similarly, building incentives for the supply chain member into the smart contracts, or creating a blockchain system which offers value to the supply chain members, may also be a means of mitigating collaborative challenges (Treiblmaier et al. 2021). However, some case study research has shown that it is actually more important that there is a perception of value to be realised by the supply chain member; as the deployment lead and the supply

chain member may disagree on what constitutes value (Clohessy & Acton, 2019). There is also evidence of supply chain members acting as a driver for blockchain adoption as opposed to a barrier. Wamba et al. (2020) note how supply chain members may pressure a deployment lead organisation to adopt blockchain technology; whereas Nayal et al. (2021) found that a close relationship with supply chain members may be a driver of blockchain adoption.

One commonality between several literatures that discuss collaboration in the context of blockchain deployments throughout supply chains is that of trust (Hastig & Sodhi, 2020; Queiroz & Wamba, 2019; Yadav et al., 2020; Treiblmaier et al., 2021; Wang et al., 2019). However, these studies do not focus on trust specifically, and as a consequence, these studies do not differentiate between integrity-based trust and competence-based trust. Further, some studies include trust, however, they are exclusively including measurements that pertain to trust in technology, as opposed to trust in an organisation (Francisco & Swanson, 2018; Lu et al., 2021; Nayal et al., 2021; Wang et al., 2019; Wong et al., 2020b). Lack of trust between deployment lead and supply chain member found to be a driving barrier for a wide array of external supply chain issues (Yadav et al., 2020). However, trust was linked to cultural dynamics as in India, a trusting relationship between deployment lead and supply chain member increased behavioural intention to adopt blockchain; whereas in the USA, a trusting relationship did not increase likelihood of blockchain adoption (Queiroz & Wamba, 2019). This may be evidence that different cultures have different value systems and that the blockchain solution needs to be compatible with the value system of the supply chain member that is being onboarded to the network. Alternatively, trust was also discussed as a solution to issues which may occur in onboarding. Treiblmaier et al. (2021) reasoned that the development of trusting relationships can mitigate collaboration and cultural issues when coupled with clearly defined rules of engagement with the blockchain. Likewise, Wang et al. (2019) also found that onboarding is easier in in circumstances where trust is present between deployment lead and supply chain member.

3. Research questions, research aim, and research objectives

Research Question 1: What are the inhibitors to the successful deployment of a blockchain throughout a supply chain?

Research Question 2: How do causal mechanisms cause the inhibitors to the successful deployment of a blockchain throughout a supply chain to occur?

Research Question 3: What are the actionable best practices which can be implemented to mitigate the most prominent inhibitors to the successful deployment of a blockchain throughout a supply chain?

Research Aim: The aim of this research is to understand the reasons why blockchain technology can fail to be deployed throughout a supply chain by investigating the main obstacles which impede this process from a variety of key stakeholder perspectives. The analysis is conducted through the lens of an adapted version of the TOE theoretical framework for technology adoption by accounting for blockchain related factors, such as supply chain governance, within the framework; whilst also increasing the specificity of extant publications into blockchain deployments throughout a supply chain by differentiating between competence-based trust and integrity-based trust. This research also captures some industry-tested novel approaches which can be actioned to mitigate these barriers in order to increase the likelihood of the successful deployment of blockchain technology throughout a supply chain. As a result, evidence related to the deployment, maintenance, and utilisation of blockchain technology within a supply chain setting is analysed.

Research Objectives (RO):

Table 4: Research objectives

Research Objective	Description
RO1	To identify the most common phases that the deployment of a blockchain throughout a supply chain commonly goes through and to understand the key tasks and objectives at each phase of the deployment.
RO2	To develop and present a template to explain the most prominent inhibitors of the deployment of a blockchain throughout a supply chain.
RO3	To make recommendations for the successful deployment of a blockchain solution throughout a supply chain by presenting a framework, in the form of a series of tables, that can be used to aid in the deployment of a blockchain system throughout a supply chain by addressing some of the most prominent inhibitors to the deployment of a blockchain throughout a supply chain that were identified in RO2.

3.1. Theoretical framework – Technology-organisation-environment

First presented by Tornatzky & Fleischer (1990), the TOE Framework posits that an organisations decision to adopt a new technology is influenced by the technological, organisational and environmental contexts. As explained by Oliveira and Martins (2011), the technological context includes all technologies available to the organisation which is seeking to adopt the new technology. This includes technologies present within the focal firm as well as those in the external market place. The organisational context refers to features, characteristics, and resources within the organisation. Baker (2012) explains that this commonly includes aspects relating to the employees, organisational structure, communication lines, resource slack, and organisational size. Lastly, the environmental context refers to factors which are external to the organisation, but which affect the organisation. This often includes governmental regulation, industry specific factors, market competition, and required labour availability.

The TOE framework has been prominently featured in research in a variety of contexts. The model has also been applied in blockchain research conducted in developed economies, such as India (Bhardwaj et al., 2021; Chittipaka et al., 2022; Kulkarni & Patil, 2020); China (Deng et al., 2022; Lu et al., 2021; Xia et al., 2022); and Germany (Holotiuk & Moormann, 2018), as well as developing economies, such as Nigeria, South Africa, and Thailand (Bag et al., 2022; Orji et al., 2020; Suwanposri et al., 2021). Thus, the framework is well established in the empirical literature on blockchain and other relevant technologies, and is evidenced as having global applicability.

As noted by Baker (2012), the TOE framework is versatile and as a result, there is divergence between publications with regard to (1) the frameworks specific subcomponents and (2) the ways in which the framework is applied. For example, whilst scholars agree on the three main categories of Technology, Organisation, and Environment, there is no definitive list of factors within each of these categories which allows for freedom in customising the framework to the research context. One example of this in the blockchain in supply chain literature is in the work of Saberi et al., (2019) where the authors adapted the TOE

framework to be specific to the challenges in deploying a blockchain system throughout a supply chain. Thus, they included an additional category of interorganisational factors to account for the fact that the deployment of a blockchain throughout a supply chain requires the onboarding of supply chain members to the blockchain. As a result, subcategories of data disclosure, cultural differences, coordination challenges, supply chain sustainability challenges, and customer awareness were included in their model, despite not being prominently featured in the TOE framework in the wider literature.

The TOE model is used to frame research in different ways within qualitative studies. In the qualitative portion of their research, Dehghani et al. (2022) identified drivers and deterrents of blockchain technology and categorised these into a single table using the TOE framework. Alternatively, Ganguly (2022) conducted a qualitative study to analyse blockchain adoption barriers in the Indian logistics sector. Instead of using the TOE framework to explain adoption, the author used the TOE framework to categorise the barriers organisations face when trying to deploy blockchains in this context.

The TOE framework has also been tested in quantitative studies. Lu et al. (2021) used SEM of survey data to test the positive influence of some TOE components on an organisations intention to adopt blockchain in China. Similarly, Malik et al. (2021) used SEM to test the influence of TOE constructs on organisation intention to adoption blockchain in Australia. Likewise, Chittipaka et al. (2022) used SEM to test the determinants of blockchain adoption, specifically in a supply chain setting. Alternatively, Orji,et al. (2020) used the analytical network process to understand which factors of the TOE network influence adoption of blockchain in Nigeria.

When studying blockchain technology, some scholars have elected to included additional contexts within the framework as well as the original technology, organisation, and environment contexts. Seshadrinathan & Chandra (2021) included trust as an additional context within their TOE framework, reasoning that any deployment of technology requires a degree of faith to be placed into the new technology (Bahmanziari et al. 2003); whilst Treiblmaier et al. (2021) included an inter-organisational context based on the proceeding work of Saberi et al. (2019).

Several scholars have stated how the TOE framework is useful to understand the blockchain adoption process (Clohessy & Acton, 2019; Hader et al., 2021). As a result, this research extends on the proceeding research that seeks to understand the challenges organisations face when attempting to deploy a blockchain throughout their supply chain, and used the TOE framework as a basis for the interpretation of the results.

3.2. Theoretical framework – Integrity-based trust and competence-based trust

One of the challenges that faces scholars who research interorganisational trust is that the trust construct requires the author to provide their own subjective definition that is often dissimilar – to varying degrees - from previous research. Despite this subjection, there are two main themes of trust that occur with greater prominence. One strand of research revolves around a form of trust that is grounded in social factors whilst the other advocates the substitution of social trust forms with rational calculation. This is best evidenced in the historical literature by how a series of publications were released which championed a specific form of trust whilst simultaneously discrediting opposing theories (Granovetter, 1985; Gambetta, 1988; Williamson, 1985; 1993). Since then, some research disciplines, such as management, have transitioned toward researching these trust forms simultaneously. However, this trend is not replicated in all disciplines. This could be explained by what Zaheer & Harris (2006) explain as being the different objectives of the economics, organization, and sociology disciplines as they are developed from different theoretical backgrounds. For instance, the economics discipline still tends to favour approaches consistent with the work of Williamson (1985; 1993), whilst Grafton & Mundy (2016) note that in the management control literature, Tomkins' (2001) view of trust has remained generally unchallenged. Before discussing how these two ideologies impact interorganisational relationships, it is first necessary to discuss what trust is - in the context of commercial exchange between organisations - and the theories and assumptions that underpin this definition. There is a degree of consensus on what trust actually is. For instance, social trust advocate Luhmann (1979), reasons that trust is the term used to

describe a belief that expectations will be met. This view of trust could be considered to be analogous in that the trusting agent either does, or does not, believe their expectations will be met. Gambetta (1988) increases the specificity of this definition by reasoning that the subjective probability that expectations will be met is not absolute. This definition acknowledges circumstances where the trusting agent is not entirely sure of the partner agent's actions. If the above definitions of trust are to be employed, then John Dunn reasons that it is compulsory to acknowledge that there is an underlying assumption that the trusted agent is capable of betrayal (Gambetta, 1988). The betrayal construct is significant as this is input into what is coined the credible commitment problem. Thus, it is important to establish a credible commitment between organisations for trust to be present (Granovetter, 1985). This could be attained through inclusion of a minimal level of information about an opposing agents' behaviour (Tomkins, 2001).

3.2.1. Overview of integrity-based trust

The construct integrity-based trust being applied in this research is grounded in in socially embedded trust (SET) which is an evolution of the early work by scholars such as Luhmann (1979) and Granovetter (1985). This form of trust is linked to the concept of *embeddedness*, a term first coined by (Granovetter, 1985) and later extended to socially embedded trust by Zhong et al. (2017). Embeddedness is a concept where social relations are embedded within organisational institutions. Granovetter (1985) cites *embeddedness* as having close association with two previous theorems in the literature; both of which are associated with Marxist theology (Carrier, 2018).

Firstly, the embeddedness concept concurs with the substantive definition of economics provided by Karl Polanyi (1944) in his work, 'The great transformation'. Substantive economics theories hold that individuals interact with their society and environment. Likewise, embeddedness holds that interorganisational behaviour is embedded in interpersonal relations (Granovetter, 1985). However, some more recent theories within the socially-embedded literature have contested the narrative that IORs are necessarily

interpersonal, by placing less emphasis on this component than Granovetter did (eg. Connelly et al., 2018). The second concept that embeddedness is built on is the theory of *moral economics* which was increasing in popularity, thanks to much cited publications like '*The moral economy of the English crowd in the eighteenth century'* (Thompson, 1971) and '*The moral economy of the peasant'* (Scott, 1976), throughout the fifteen years prior to Granovetter's (1985) embeddedness theorem. Carrier (2018) points to one of the outcomes of moral economics being relationship generation that promotes the likelihood of repeat business. The time-bound component of moral economics and SET is acknowledged by Tomkins (2001, p165) who stated that trust is an interpersonal "assumption of functional continuity" between organisations. Likewise, Gulati & Sytch (2008) acknowledge that social institutions form between organisations overtime. Within these social institution's partners develop expectations of each other, which correlates with the acceptance of vulnerability (Zhong et al., 2017). In line with this concept, it can be argued that embeddedness places emphasis on 'the we' in the interorganisational relationship. To summarise, socially embedded trust is developed through repeat interactions where goodwill-trust is developed, and this causes partners to accept vulnerability as they predict that the other organisation will act in an expected way.

"when people engage in economic transactions with others, those transactions can generate a relationship with those others and an obligation to transact again in the future" (Carrier, 2018, p32)

One characteristic of SET is that it is heavily related with the employment of minimalistic contracting as an accountability mechanism to govern the relationship. This is a consequence of research that shows contracts can have negative impact on socially embedded trust between partner organisations (Lui & Ngo, 2004; Lumineau, 2017). A second reason is that it is not feasible to account for every possible eventuality when designing a long-term contract with a partner organisation and that organisations often arrive at agreements not mentioned in the contract as a means of settling disputes (Granovetter, 1985). This view is largely built on the contracting research of Macaulay (1963) who stated that it is in the interest of business partners to avoid legal action if they have a desire for future business with another organisation. However, as Tomkins (2001)

points out, litigation has become significantly more frequent since Macaulay (1963) made this statement.

A second characteristic of embeddedness relates to betrayal. As noted by contributors such as Kramer (1994) and Searle & Ball (2004), high SET can be violated by a single dishonest behaviour. This is extended by Connelly et al. (2018) who explain how a single dishonest behaviour by one department within an organisation, leads that partner to be viewed as being dishonest across all departments. Thus, it can be argued that socially embedded trust is *honesty-critical* in that a single act of dishonesty can result in a complete failure within the relationship.

3.2.1.1. Form of socially embedded trust being applied in this research

Analysis of the extant interorganisational trust literature reveals that there continues to be debate about how best to classify the various trust forms. This is evidenced within the broad categorisation of embedded trust as there are frequent inconsistencies between scholars. Several authors have studied what they call 'goodwill' trust as their preferred label for a form of trust that is grounded in the logic of social-relationships between organisations or individuals within organisations. Within quantitative research it is generally considered good practice to report the selected measures, this makes for easy comparison between the various forms of social-based trust. One such example is Lui & Ngo (2004) who classify 'goodwill' trust as being interpersonal. They observe this by measuring the relationship between individuals at a buyer organisation and a supplier organisation within several supply chains. Connelly et al. (2018, p926) state that what they call 'integrity-based trust' is equivalent to what Lui & Ngo (2004) classify as 'goodwill trust'. However, Lui & Ngo (2004) focus on interpersonal measures of trust whilst Connelly et al. (2018) focus on interorganisational measures of trust. This is a difference in observed indicators and not necessarily different latent constructs. However, if the reader holds the belief that interpersonal trust and interorganisational trust are fundamentally different, then it should

be argued that the true latent constructs they each observed are also different. This inconsistency of what is actually observed is also evidenced in Poppo et al. (2015). The authors investigate what they call “relational trust”; however, it is not clear whether they are investigating this at an interpersonal level or an interorganisational level.

Whilst often research categorises social forms of trust as being interpersonal and others interorganisational, some scholars have blurred the lines between these two stances. The work of Tomkins (2001) provides a nuanced approach to this categorisation by acknowledging the similarities and differences between the two stances. Ultimately, Tomkins (2001) argues that interpersonal trust evolves into interorganisational trust as it becomes increasingly dissimilar throughout the lifecycle, before transitioning back toward being more interpersonal. Graphically this would be represented by an inverted U-shape as the organisation matures. Another example that holds interpersonal trust and interorganisational trust as being interlinked is evidenced in the work of Zhong et al. (2017). This is achieved through interpersonal trust between the individuals within the organisations being a measured input in determining what they coin ‘goodwill-based trust’. Thus, this view holds that interpersonal trust and interorganisational trust are different, but that one has an impact on the other.

To this point, the categorisations have mainly differed along the interpersonal-interorganisational dimension; however, another key differential is also present in how social-bound trust forms are categorised. This second dimension is related to the role of the value construct within an IOR. If the importance of value alignment were to be considered a spectrum, then some scholars place high emphasis on this construct whilst others place little-to-no emphasis on this construct. The most extreme versions of this can be seen in the respective research of Poppo et al. (2015) and Lui and Ngo (2004). Poppo et al. (2015) measure what they categorise as ‘relational trust’. As the name suggests, the authors focused on the relationship between organisations; however, this was done by measuring ‘shared identity’. Contrasting, Lui and Ngo (2004) overlook the importance of shared values in their research design as they do not include any metric for measuring value alignment. Unlike the previously mentioned authors, Connelly et al. (2018) take a middle of the road approach as they include measures relating to the subjection the trusted partner will be distrustful, alongside the degree of value alignment. This could show that the authors

believe value alignment is an important measure for gaining insight into 'integrity-based trust' but, they acknowledge that there may be other important factors.

It is also hypothesised that values could play a different role in IORs than is outlined above. The qualitative work of Tomkins (2001, p173) develops a four-stage IOR life cycle that focuses on the relationship between trust and information. Tomkins states that an "understanding of personal values" is one information type needed to transition toward a degree of inter-dependence higher than "low". The key distinction here is the use of the term "understanding" by Tomkins, instead of "alignment" which is also features in the literature (Tomkins, 2001, p173; Connelly et al. 2018, p929). The increased prominence of "alignment" in IOR literature suggests that the organisations need to first understand – as stated by Tomkins (2001) – but then at the higher stages of trust, these values must align and that simply understanding the partner agents' values is insufficient.

Contemporary research into social-based trust has challenged the traditional embeddedness theorem by shifting the orientation from social interactions that produce interpersonal trust, toward the inclusion of value alignment (Poppo et al., 2015; Connelly et al., 2018). It can be seen that some researchers view social-based trust as being interpersonal (Granovetter, 1985; Luhmann, 1979; Lui & Ngo, 2004; Lumineau, 2017; Tomkins, 2001; Zhong et al., 2017), others view it as being interorganisational (Connelly et al., 2018; Zhong et al., 2017), others view it as spectrum-like (Tomkins, 2001), and others view one as input for the other (Zhong et al., 2017). Likewise, some researchers place much greater importance on the role of value alignment in their categorisations of social-based trust whilst others place much less importance on value alignment. Consistent with Tomkins (2001), this research holds the position that the term integrity-based trust being applied in this research is both interpersonal and interorganisational in nature. Thus, it is dependent on trust that actors within the collaborating organisation will act in your interest. The integrity-based trust being applied in this research also features the need for value alignment. One way this inclusion of value alignment manifested within this research was the decision to incorporate cultural differences within the collaboration construct in the literature review.

3.2.2. Overview of competence-based trust

The form of competence-based trust being applied in this research is grounded in calculativeness which is an evolution of the early work by scholars such as Williamson (1985). Many scholars advocate that a logical approach toward interorganisational transactions is more effective than its embeddedness counterpart (Connelly et al., 2018; Grafton & Mundy, 2016; Poppo et al., 2015; Williamson, 1985; 1993; Zhong et al., 2017). One predominant ideology is that of calculativeness, or the calculative strategy, which is the given term for the application of the transaction cost economics (TCE) theorem toward interorganisational relationships.

In his book 'The economic institutions of capitalism', Williamson (1985) was able to synthesise ideas from the economics, law, and organisational disciplines into his version of transaction cost economics. In economics, Williamson was able to operationalise the work of Robert Coase (1937). Coase posited that firm-to-market boundaries were established based off of transaction costs. However, this was not then explored to determine what factors influence transaction costs. Because of this, it was not possible for organisations to develop strategies based off of Coase's work. What Williamson (1985) was able to do was operationalise this by explaining the underpinning factors that influence transaction costs. One contribution of this is that of vertical integration as a strategy to control transaction costs, by extending the boundaries of the organisation. One factor that Williamson identified as underpinning transaction costs was asset specificity which is an extension of the work of Kenneth Arrow (1971) who was concerned with opportunism in transactions. Arrow attributed this to information and trust dimensions as neither party has information of the true integrity of the other. This was largely an extension of previous research in the organisational literature that described a concept of 'intended rationality' which was later coined 'bounded rationality' (Barnard, 1938; Simon, 1957). This concept was that agent's decision making is bound by the information that they have available.

One other development that was occurring in the period prior to Williamsons publication was in the field of contract law. Namely, acknowledgement of the inability to account for all future eventualities when designing a contract (Cox, 1958). However, Summers (1969)

approached the contract design problem from a contractual transaction perspective as opposed to a scenario perspective. Summers reasoning was embedded in the logic that the number of principles in contracting transactions are few and this meant that contracts could account for more eventualities by being general regarding scenarios.

Williamson (1985) synthesised and operationalised the above ideas into his version of transaction cost economics. TCE does not refer to an embedded form of trust. Instead TCE advocates for the substitution of trust with contractual safeguards. The calculative strategy can then be considered the strategic operationalisation of TCE toward IOR strategy. Williamsons (1993) calculativeness requires the concurrent determination of three inputs – (1) price, (2) hazards, and (3) safeguards. These three inputs are then evaluated together to determine if the net gains of the transaction are positive. Williamson (1993) classifies this concept as being 'competent calculativeness' when four criteria are met. (1) Agents are aware of outcomes and their possibilities. This could be considered similar to the subjective probability component proposed by Gambetta (1988). (2) Agents safeguard against hazards and take actions that can maximise the potential benefit. (3) Agents only proceed with the exchange if they expect a net gain outcome. (4) Agents only proceed with the exchange with the agent that offers the largest net gain outcome.

Whilst Williamson's (1985) work is largely built on previous publications by scholars such as Arrow (1971), Coase (1937), Bernard (1938), and Summers (1969). The application of this into the calculative strategy also took influence from game theoretic approaches to interorganisational strategy by contributors such as Kreps (1990) and Dasgupta (1988). Kreps designed a game where the players had to evaluate pay-offs to decide whether to act in a certain way. The outcome of the game was that one player should act in an opportunistic way as this maximised net gain. However, the main contribution of Kreps was made by switching the game so that after each game, there was a high probability of another game, providing neither player acted opportunistically in the previous game. This resulted in the solution involving both participants choosing to act in a *trustworthy* way. This is an example of calculating the potential pay-offs and hazards to evaluate whether to engage with a partner. In terms of TCE, this can be considered the price and hazard dimensions as the payoff (price) is evaluated against the threat of opportunism (hazard).

Calculativeness uses contractual safeguards as a substitute for 'trust', making calculativeness a *trustless* approach toward interorganisational relationships. The criticism of contracting not sufficiently accounting for future eventualities – provided by Macauley (1963) amongst others - is one which Williamson (1993, p460) directly addresses in his statement, "…although complex contracts are unavoidably incomplete, a farsighted approach to contract is often feasible… and this relieves problems associated with incomplete contracts". Williamson (1993) critiques Dunn (1988) for his use of the word betrayal in reference to calculative strategy, as Williamson argues betrayal should be reserved for personal trust as it is very damning and hard to resurrect a relationship after betrayal. This is consistent with the SET literature that could be considered to be honesty-critical. Williamson (1993) instead reasons that *breach of contract* is the more accurate term for betrayal in calculative relationships. This argument is reflected in recent literature that analyses calculativeness in interorganisational relationships (Grafton and Mundy, 2016).

3.2.2.1. Form of calculative trust being applied in this research

Like SET, the calculative based approach has seen some development since its inception; however, it could be argued that there is less differentiation in interpretations. This is because calculative strategy is not as complex, in that it has fewer considerations because it separates the social factors from the economic factors. One consequence of this is that there is no debate in the calculative literature as to whether it is interpersonal or interorganisational – as it removes the personal substantivism consideration. Thus, there is agreement amongst calculative scholars that this trust form is interorganisational (Connelly et al., 2018; Poppo et al., 2015; Williamson, 1993). The main differentiations in how calculativeness is categorised are terminological. This is best evidenced in how Poppo et al. (2015) define calculative trust as being based on rewards and penalties. This shares similarities with Williamson (1993); however, Williamson reasons that the term '*calculative trust'* is paradoxical and redundant. This is because his form of calculativeness is grounded in the logic that contractual safeguards operate as substitutes for conventional trust –

making calculativeness a *trustless* methodology. By this logic it does not make sense to refer to calculativeness as calculative trust.

One unique example is that of Connelly et al. (2018) who elect to include resource dependence theory (RDT) in their competence-based trust - which is the authors preferred equivalent of calculativeness. However, the issue with this is best exemplified by RDT and TCE predicting different outcomes about opportunism when an agent engages with another agent that it is dependent on for resources (Zhong et al. 2017). Thus, whilst Connelly et al. (2018) combines RDT and TCE into competence-based trust, Zhong et al. (2017) separates them and researches them individually. Despite this, consistent with Connelly et al. (2018) and Lui and Ngo (2004), this research holds the position that resources and transaction cost economics are coupled together in competence-based trust which is defined in this study as "an expectation that a partner has the technical skills, experience, and reliability needed to fulfil its obligations" (Connelly et al., 2018, p920). This is because introducing a third theorem was considered outside of the scope of this research, so instead a coupled approach was taken.

3.3. Contributions to theory and industry

The overwhelming majority of research has employed the TOE framework to determine or understand predictors and drivers of blockchain adoption (Bag et al., 2022; Barnes III & Xiao, 2019; Dehghani et al., 2022; Fernando et al., 2021; Holotiuk & Moormann, 2018; Kulkarni & Patil, 2020; Lu et al., 2021; Seshadrinathan & Chandra, 2021; Xia et al., 2022). Fewer studies have been conducted using TOE which seek to understand the predictors and drivers of blockchain adoption, specifically in a supply chain setting (Bhardwaj et al., 2021; Chittipaka et al., 2022; Deng et al., 2022; Lin, 2023; Orji et al., 2020; Suwanposri et al., 2021; Taherdoost, 2022). Moreover, only a limited number of empirical studies have been conducted which apply the TOE framework to understand challenges organisations face when deploying blockchain systems in a supply chain setting (Clohessy & Acton, 2019; Ganguly, 2022; Kouhizadeh et al., 2021; Treiblmaier et al., 2021). Of this body of research,

only two studies were conducted which apply an inductive approach to develop conclusions from the data (Clohessy & Acton, 2019; Ganguly, 2022). This research differentiates from previous studies in 2 main ways in order to make a theoretical contribution. (1) In Research Questions 1 and 2, the analysis of the interview transcripts is conducted by using the adapted version of the TOE framework, which has increased specificity to blockchain deployment in supply chains, as an *a priori* starting point to interpret the collected evidence (Saberi et al., 2019). Thus, unlike the aforementioned studies, this research accounts for factors within the TOE framework which are specific to blockchain technology – such as Inter-organisational barriers which are not featured within the Clohessy & Acton (2019) or Ganguly (2022) studies. As a result, the *a priori* application of the Saberi et al. (2019) TOE framework permits new insights into how inter-organisational barriers can impede the deployment of blockchain solutions throughout supply chains. (2) Additionally, retroductive and abductive inferencing is employed to account for additional theories which can be used to explain Research Question 2. For example, the adapted TOE framework is modified in order to explain the collected evidence by incorporating additional theories from the interorganisational trust literatures, namely competence-based trust and integrity-based trust, into the TOE framework to better explain the causal mechanisms of blockchain adoption challenges in supply chains. As a result, this research extends upon previous blockchain in supply chain literature by differentiating between integrity-based trust and calculative trust in order to understand how these trust forms can impact the deployment of blockchains in supply chains whilst simultaneously extending the trust literature by applying the theories of integrity-based trust and calculative trust in a new setting.

Additionally, Research Question 3 makes theoretical and industry contributions by further deepening the recommendations to academics and industry practitioners about how to undertake the deployment of a blockchain solution throughout a supply chain. This is achieved by providing insight into blockchain best practices which can be actioned to minimise the impact of different barriers which may inhibit the successful deployment of the blockchain solution. Previous research has made similar recommendations for industry (Treiblmaier et al., 2021), however the recommendations made in this research are different for 3 main reasons: (1) In accordance with Research Objective 3, these recommendations of best practices are made in the format of a framework which can: (a) be used by industry

practitioners to aid in the deployment of a blockchain solution; and (b) be extended upon in subsequent research by other academics. Further, the theoretical framework is developed through retroduction and abductive inferencing of the collected evidence meaning that it accounts for theory which is present within this study which may have been omitted from previous research – such as integrity-based trust and competence-based trust. (2) This research is wider in scope in that it also accounts for multiple industries rather than being focused on just the agri-food sector. And (3) this study interviewed participants who have held a variety of different key stakeholder positions which affords a varying perspective to the one captured in their research. In this vein, this research is a response to the authors call for future research to account for the perspectives of more stakeholder groups than were accounted for in their study.

This research also accounts for some of the limitations in previous research in order to produce several minor theoretical contributions. Firstly, the research design permits insight into how the objective of the blockchain solution can impact the prominence of different barriers. Currently there are few journal articles (Kouhizadeh et al., 2021; Van Hoek, 2019) which make the suggestion that the type of blockchain solution can alter the prominence of different barriers. However, this is not something prominently recognised in the literature as the majority of journal articles do not state what the objective of the blockchain actually is; beyond stating it's a blockchain project in a supply chain setting. In industry there are many examples of different types of blockchains in supply chains – logistics blockchains for product tracking from source to consumer; blockchains for supply chain finance and blockchains featuring payment rails; blockchains which aid in the capturing of data for Economy of the Common Good (ECG) reporting; and many others. This research is designed to facilitate more detailed scrutiny into how the blockchain objective can affect the prominence of different inhibitors of blockchain deployment in supply chains by acquiring a comprehensive description of the cases where blockchain was deployed, and then through probing to gain increased understanding of contextual factors.

Secondly, this research captures data which is, to the best of this researcher's knowledge, currently unavailable at this scale in the extant literature. Some of the insights in this research are from the perspective of experts who have worked on blockchain deployments which have moved beyond a pilot grade deployment into a production-grade blockchain

deployment throughout a supply chain. The majority of interview research into blockchain barriers to deployment in supply chains can be categorised in three ways: (1) It is conducted at a proof-of-concept or pilot level (Van Hoek, 2019). (2) It is conducted with interviewees who do not necessarily have first-hand experience with blockchain (Wang et al., 2019; Treiblmaier et al., 2021). Or (3) it does interview experts who have implemented blockchain but it is at a smaller scale and does not state the blockchain level of deployment (Clohessy & Acton, 2019). This is largely as a consequence of the infancy of the technology coupled with the fact that so few projects have moved beyond pilot grade implementations into production grade deployments. This point is perhaps best explained by Interview Participant 11b in this research as when asked if he has worked on blockchain deployments which have moved beyond pilot grade implementations, he replied "Has anyone? I'm being cynical". However, several of the interview participants involved in this research have worked on projects which have moved beyond a pilot grade implementation, capturing an insight which is currently sparsely represented in the literature. One implication of this is that this research is not specific to one single industry as that would have dramatically reduced the number of available experts who have worked on projects which have worked on production grade blockchain deployments. However, coincidentally, the majority of participants have worked on blockchains in the agri-food sector.

Lastly, the research design accounts for limitations in the extant literature in that there is an underrepresentation of exploratory interview data and an underrepresentation of interviewees where the participants have first-hand industry experience working on projects where blockchain solutions have been deployed. Currently, the majority of the research which uses primary data in blockchain in supply chains is survey research (Biswas & Gupta, 2019; Wamba et al., 2020; Kamble et al., 2019; Kouhizadeh et al., 2021; Nayal et al., 2021.; Queiroz & Wamba, 2019; Treiblmaier et al., 2021; Wong et al., 2020a; Wong et al., 2020b). Further, the majority of the relevant survey research uses samples which do not require any experience in implementing or working with blockchain solutions in supply chains (Kamble et al., 2019; Van Hoek, 2019; Wong et al., 2020a; Wong et al., 2020b) . This can be attributed to the nascent nature of industry cases where blockchain is being adopted. This makes it difficult to attain a sample which all have first-hand experience implementing and working with these solutions; whilst being large enough to enable statistical generalisation.

The implication of this is that the research body does not accurately portray the views of experts in blockchain deployment and supply chain management. Also, there are few papers which focus on qualitative techniques in order to explore the topic and aim to provide a depth of understanding (Clohessy & Acton, 2019; Treiblmaier et al., 2021; Van Hoek, 2019; Wang et al., 2019). Of these papers, one of them focuses specifically on blockchain pilots (Van Hoek, 2019), one focuses on cross case comparisons between organisations who have and have not implemented blockchain projects (Clohessy & Acton, 2019), one focuses of interviewing Supply Chain and IT experts to understand blockchain adoption (Wang et al., 2019), and lastly one interviewed supply chain experts on blockchain adoption (Treiblmaier et al., 2021). Consequently, only van Hoek (2019) and Clohessy and Acton (2019) capture the perspectives of individuals who have first-hand experience in implementing blockchain technology. This research design extends upon the qualitative research of van Hoek (2019) and Clohessy and Acton (2019) as the use of interviews and supporting qualitative techniques enables the exploratory understanding of blockchain technology though the frames of meaning adopted by the involved research participants. In achieving this, this research aims to develop this by capturing the perspectives of three identified key stakeholder groups: (1) Deployment Leads - Individuals who work at the focal organisation who are implementing the blockchain solution and who have first-hand experience working with, and restructuring, the business around the solution. (2) Technology Providers - Individuals who are employed to build the blockchain solution. And (3) Advisors - Individuals who work as consultants or advisors to organisations and/ or Governments who have deployed blockchain solutions.

4. Methodology

This methodology chapter is divided into six subsections which each present the approaches which were utilised in this PhD to collect and analyse data, as well as to justify the decision-making choices. Section 4.1 presents the philosophical assumptions and the approach to theory development being applied in this research. Section 4.2. reports the various approaches taken to recruit participants. Section 4.3. outlines the evidence collection. Section 4.4. details the data analysis process. Section 4.5. outlines the main ethical considerations and explains the data management process. Lastly, Section 4.6 summarises the methodology chapter and presents an accompanying diagrammatic representation of the methodology procedures.

4.1. Philosophical assumptions

This research applies the philosophical assumptions of Critical Realism. Critical Realism assumes a stratified realist ontology, a relativistic epistemology, and a value-laden axiology (Archer et al., 1998; Bhaskar, 2008; Reed, 2005; Saunders et al., 2023). Critical Realism was developed by Bhaskar (1978) in response to the discourse surrounding the limitations of positivism and constructivism at the time (Denzin & Lincoln, 2017). In their work on competing philosophical assumptions, Hunt (2003) notes how Critical Realism has since been developed through the works of several scholars who have each presented their own variations of the philosophy (Archer, 1995; Bhaskar, 2008; Collier, 1989; Lawson, 1997; Sayer, 1984; 1992; 2000). However, Easton (2010, p121) states how the fundamental objective of Critical Realism philosophies is to produce an explanation of events by understanding “what caused those events to happen?”. Some of these authors then had their works on Critical Realism further developed and applied to specific contexts, either through their own subsequent publications, their collaborations with others, or from other scholars using their theories as a framework for other research. One such example is in the work of Easton (2010), who sought to adapt the work of Sayer (1984, 1992, 2000) to case-

based research in management. This research applies the version of Critical Realism presented by Easton (2010) which is heavily inspired by the seminal works of Andrew Sayer (1984, 1992, 2000), and Roy Bhaskar (1978; Archer et al., 1998). The following presents the ontological, epistemological, and axiological assumptions made within this study, alongside specific details of how these assumptions manifest within this research.

4.1.1. Ontological assumptions and implications for this research

Ontological assumptions are about the nature of reality (Saunders et al., 2023). Bhaskar posits that reality is external, but that it cannot necessarily be directly measured or accessed. Thus, in Bhaskarian Critical Realism, reality is differentiated into three domains – the Empirical, the Actual, and the Real - according to how the information within them can be accessed and understood (Kringelum & Brix, 2020). The first category is the Empirical. This Empirical domain denotes events which are directly observed, experienced, or participated in (Bhaskar, 1978). Alternatively, the Actual domain details all events which can occur, irrespective of whether these events are actually observed (Bhaskar, 1978). Lastly, the Real domain contains information which pertains to the underlying causal structures and mechanisms which cause events in the Actual; the effects of which may be observed in The Empirical. Thus, the mechanisms within the Real cannot be directly observed, however their effects can be understood through the perspective of the researcher(s) (Ackroyd & Karlsson, 2014).

As stated previously, the objective of Critical Realism is to explain events by trying to gain insight into the actors and mechanisms which caused those events to occur (Easton, 2010). In order to achieve the objective of Critical Realism, Sayer (1984) produced a diagrammatic model (Figure 1) to show how events can be explained by causal mechanisms in the Critical Realist philosophy. Within the model, the scholar defined the concepts of entities, structures, causal powers, liabilities, conditions, mechanisms, and events. Easton (2010, p125) states that entities are “tangible and intangible, social or physical, dormant or active”. Thus, they are broad and must be defined within each study (Brøns Kringelum & Brix, 2020).

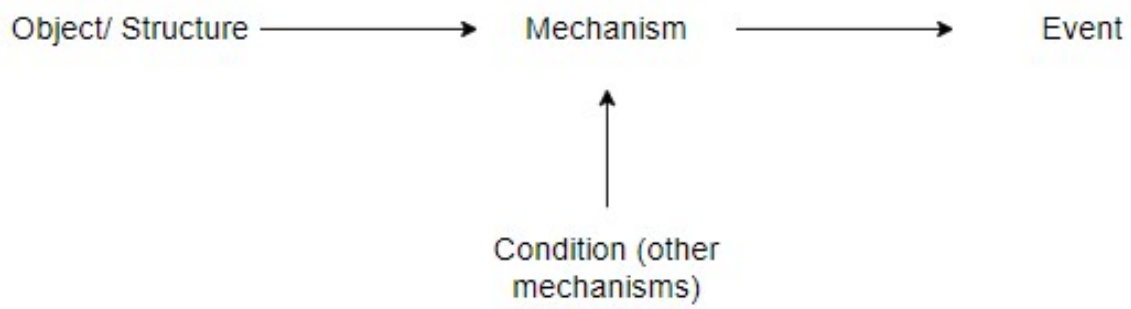

Figure 1: Causal Mechanisms in Critical Realism (Sayer, 2000, p15)

In this study, the entities are the various organisations involved in the deployment of a blockchain solution throughout a supply chain. These are Deployment Lead, Technology Provider, Supply Chain Members, and Consultants/ Advisors. There is a degree of theoretical flexibility in how different entities are classified (Easton, 2010). The blockchain itself could be classed as belonging to one of the aforementioned entities, and be internal to that object; alternatively, the blockchain could be considered as a separate entity that is not intrinsic to any other object. In this study, the blockchain, and its accompanying novel technologies, were classified as their own object. Thus, the blockchain was not considered to be intrinsic to any single other object. The rationale for this decision was that at different stages of the lifecycle of the blockchain, it could be classified as belonging to a different object. For example, prior to deployment the blockchain would have been considered as belonging to the Technology Provider; whilst post deployment the blockchain would be a sub-entity of the Deployment Lead and the Supply Chain Members. Thus, to remove any confusion, the blockchain was treated as its own entity that each of the other entities interacts with.

Within each of these entities, there are structures. Structures are entities and practices which are internal to an entity, which each have causal powers that can influence events to occur (Sayer, 1992). In this study, this includes the organisational management structures and departmental structures of the entities which are organisational entities, and the accompanying technologies of the blockchain entity. Any technology which existed prior to the deployment of the blockchain was classed as belonging to the organisational entity, whilst only new technologies specific to the blockchain are considered within the blockchain

entity. Further, substructures can be contained within other structures. Thus, within each department, there are individuals who each have their own relationships, personalities, and experiences.

Each entity and structure also possesses potentialities (Psillos, 2007). Potentialities refers to the causal powers and liabilities of an entity or structure. Causal powers are the ability of an entity to influence a different entity (Sayer, 2000). Conversely, liabilities refers to the susceptibility of an entity to be influenced by a different entity (Easton, 2010). In this study, the causal powers of entities are properties which can influence the successful deployment and scaling of a blockchain system throughout a supply chain; whereas, the liabilities of entities are properties which can disrupt, prolong, or prevent the successful deployment and scaling of a blockchain system throughout a supply chain. These powers and liabilities of entities and structures can be activated under specific social conditions (Fletcher, 2017). As can be evidenced in Figure 1, when a structure or entity activates its causal powers or liabilities within The Real to produce events in the Actual which can be observed in The Empirical, it is called a causal mechanism (Sayer, 2000). Causal mechanisms are the focus of Critical Realism (Archer et al., 1998). This research is aiming to understand the causal mechanisms which lead to unsuccessful deployment of a blockchain system throughout a supply chain, by acquiring reports of events which are observed by the research participants.

Events are the product of causal mechanisms under specific conditions (Sayer, 2000). In Critical Realism, events are present within the Empirical. Meaning, events can be observed by individuals. Events are the behaviours of individuals, systems, or things. In this research, there are four possible events. (1) The blockchain is not implemented throughout the supply chain. (2) The blockchain is implemented throughout the supply chain. (3) The blockchain is implemented throughout the supply chain but in a limited version. (4) The blockchain is implemented throughout the supply chain but there were significant challenges throughout the process.

4.1.2. Epistemological assumptions and implications for this research

Epistemological assumptions are about the nature of knowledge (Saunders et al., 2023). As noted by Easton (2010), this differentiated ontology has significant implications for Critical Realism epistemology. Critical Realism maintains position of epistemological relativism, meaning that facts are a product of social constructions (Bhaskar, 1989). Further, these social facts can be explained and represented by theory which is "more or less truthlike" (Danermark et al., 2005, p10). The purpose of these theories is to explain real events by identifying the causal mechanisms within the Real, through rational judgement of the observable events in the Empirical and the Actual (Archer et al., 1998). This study employed the Technology-Organisation-Environment theoretical framework as a lens to interpret the evidence through. The implications of the relativist epistemological assumptions of the differentiated reality is that, observations do not necessarily explain the Actual events and underlying causal structures. Thus, it is necessary to collect data which is sufficient in providing insight into competing explanations, and that the process of researchers collecting data through varying theoretical frameworks, and debating the explanations, is how theories which explain the Real world become more robust (Easton, 2010). Similarly, Sayer (2000) reasons that the selection of methods should be guided by the phenomenon under investigation. As a result, Critical Realism is not constrained to any particular method or approach (Reed, 2005). In critical realist research, Easton (2010, p123) reasons that as a consequence of the ontological and epistemological assumptions, research questions must be formulated in a specific way. He states that "the question must be of the form 'What caused the events associated with the phenomenon to occur'?". This phrasing places the causal mechanisms and conditions as the unit of analysis for investigation. This is consistent with the research questions in this research that seeks to understand what conditions and mechanisms causes instances where blockchains are unsuccessfully deployed throughout a supply chain.

Two approaches were used for inferencing throughout this research – retroduction and abduction. Saunders et al. (2023) states how inferencing approaches can be used in combination and that this can be advantageous. Retroduction and abduction were originally

introduced as interchangeable terms by Peirce (Burks, 1946). However, over time the definitions of these terms have shifted, making them two separate but interrelated modes of inferencing (Meyer & Lunnay, 2013). More specifically, Danermark et al. (2005) explains that when retroduction and abduction are used in conjunction with one another in Critical Realism research, this can lead to the development of new theory.

Retroductive inference is a process of analysing evidence to identify conditions where the studied phenomenon cannot exist (Meyer & Lunnay, 2013). As the objective of Critical Realism is to explain events in the Empirical through the understanding causal mechanisms in the Real, it is necessary to understand the conditions which are needed in order to create, or prevent, the event. In this instance, the studied phenomena is the barriers to blockchain deployment throughout supply chains. Thus, retroduction is used to understand the conditions which when present, inhibit the likelihood for a successful deployment of a blockchain solution throughout a supply chain. Retroductive inference in Critical Realism requires that theories must be present in the analysis process. As a result, the TOE framework was used as a starting point for data analysis. Danermark et al. (2005) details several approaches which can be used in Critical Realist research to understand the conditions that must be present in order for an event to occur, using retroductive inference. Firstly, cross-case comparisons are one approach which the authors state can reveal insights into conditions, and how these can affect the events which are observed. This study collects evidence from five different instances where blockchain has been deployed throughout supply chains. During the evidence collection from cases, each participant provided a thick description of the context of the case. This context was then often referred back to in the later portions of the interviews. Similarly, the interviewees who were not discussing one specific case, were also encouraged to share contextual information which they deemed relevant to the studied phenomenon. The second approach taken was in counterfactual thinking. Counterfactual thinking is a process of identifying conditions which are constitutive to the event, and differentiating between constitutive conditions and coincidences. This occurs though reflection by considering how the events could have changed, if different conditions were present.

In his early works, the proposer of abduction, Charlies S. Pierce, put forth that abduction seeks to develop new theory and aims to develop new ideas (Burks, 1946). This is achieved

by analysing data which is outside of the initial theoretical framework in order to introduce new ideas to the research topic (Meyer & Lunnay, 2013). The abductive process is a theory centric process which involves going from theory-to-data-to-theory (Saunders et al., 2023). The abductive approach can be considered in three iterative and non-linear parts. Firstly, abduction starts with a surprising fact that theory does not sufficiently explain (in this case, it is why do so many blockchain deployments throughout supply chains ultimately fail); following, data is collected which may be outside of the previously established theoretical framework in order to elucidate the causes of why the surprising fact occurs; before making a best prediction to explain why the surprising fact occurs and adjusting the conventional theory in order to explain the surprising fact (Peirce, 1940). The literature on blockchain deployment challenges is currently not saturated, and as a result, theories are not as tested as they would be in more mature research areas. Thus, this research is designed to facilitate the collection of evidence which does not holistically prescribe a theory onto the research, as the theory may not be the best fit due to the infancy of the research area. To achieve this, an abductive inferencing approach was taken that is consistent with the work of Meyer & Lunnay (2013), based on the earlier work of Danermark et al. (2005), which included abductive and retroductive inferencing in a single study. This manifested in two main ways. Firstly, during data analysis, evidence which was outside of the initial theoretical framework, was still analysed. The outcomes of the analysis was then used iteratively to analyse other data sets through the newly developed theoretical lens in order to discern their value to the research. Secondly, during evidence collection, when an interview veered off-topic slightly, the participants were afforded time to provide their response before the interview direction was changed back to the original question. Both of these approaches afforded the opportunity for information which was outside of the initial theoretical framing of the research to be considered in evidence collection and data analysis.

Critical Realist case studies cannot achieve statistical generalisation in their findings as they do not use samples and the objective is not to report on frequencies of occurrences; however, they do permit analytical generalisation as they are generalisable to theory (Easton, 2010). In Critical Realist case research, this occurs through understanding the causal mechanisms and the underlying conditions which are necessary to facilitate outcomes in the Empirical (Fletcher, 2017). In this study, retroductive and abductive inferencing was used to

expand on the most popular variation of the TOE framework (Saberi et al., 2019) present in the blockchain adoption in supply chain literature by accompanying additional theories, namely calculative trust and integrity-based trust, into the theoretical framework to best explain the data set in terms of the causal mechanisms which can lead to the unsuccessful deployment of a blockchain throughout a supply chain.

The TOE theoretical framework posits that an organisations decision to adopt a novel technology is a product of the technological, organisational, and environmental circumstance of the firm (Oliveira and Martins, 2011; Baker, 2012; Bhardwaj et al., 2021; Chittipaka et al., 2022; Kulkarni & Patil, 2020; Deng et al., 2022; Lu et al., 2021; Xia et al., 2022; Holotiuk & Moormann, 2018; Bag et al., 2022; Orji et al., 2020; Suwanposri et al., 2021). This was first proposed by Tornatzky & Fleischer (1990) and has since become an established theoretical framework for the study of technology adoption as a consequence of the versatility of the framework with regard to epistemological and ontological assumptions as well as the broad nature of the framework enabling the discovery or testing of a large range of data (Baker, 2012). This study applies a stratified realist ontology and a relativist epistemology consistent with Sayer's (2000) Critical Realism.

Whilst not always directly stated, previous research that has aimed to understand technology adoption has incorporated the TOE framework alongside a realist ontology (Awa et al., 2017; Kouhizadeh et al., 2021; Wang et al., 2020; Wong et al., 2020a); a relativist epistemology (Ansong & Boateng, 2018; Clohessy & Acton, 2019); and critical realism (Ansong and Boateng, 2018). Further, semi-structured interviews and case study interviews are also an established tool used to interpret datasets from a Critical Realist perspective (Brönnimann, 2022). As a result, the TOE framework is an established and versatile lens which has been applied in conjunction with the philosophical assumptions present within this study to understand technology adoption where interviews are the preferred mode of evidence collection (Baker, 2012). In this study, the abductive mode of theory making in conjunction with the a priori use of the TOE framework is one element which differentiates this research from previous studies that focus on blockchain deployments. As a result, the findings from this research are grounded in extant literature whilst also enabling the collection and interpretation of data which is previously not prevalent in the relevant literary body. This is further expanded upon in Section 5. Findings and Discussion.

4.1.3. Axiological assumptions and implications for this research

Axiological assumptions are assumptions made about values and ethics (Saunders et al., 2023). When outlining one of the eight key tenants of Critical Realism, Sayer (1992, p5) explains that social phenomena must be understood "from the researchers own frame of meaning". This statement acknowledges that any Critical Realist research must acknowledge the biases and predispositions of the researcher. Likewise, Saunders et al. (2023, p140) explains that Critical Realism recognises that "knowledge of reality is a result of social conditioning and cannot be understood independently of the social actors involved". Thus, Critical Realism holds a value-laden axiological position, meaning that it is necessary to acknowledge factors which may cause researcher biases. These include, but are not limited to, knowledge, past experiences, world views, and cultural experiences (Saunders et al., 2023). Consequently, it is necessary to develop an approach which seeks to minimise these researcher biases, in order to minimise researcher subjectivity and remain as objective as possible. This is achieved in this research primarily in two ways. Firstly, reflexive memo writing is conducted following each interview (Appendix E), which provides a brief summary of the events and key themes from the interview, and an evaluation of the interview questions which were asked and how they were delivered. Secondly, the initial template (Appendix F), and the full template (Appendix H) are included in the Appendix as a means of providing an audit trail where the progression of codes may be evaluated. Likewise, in their contingent criteriology for the evaluation of qualitative research, Johnson et al. (2006) developed a criteriology which puts forth criteria which Critical Realist research should be evaluated against. In this criteriology, the scholars state how researcher reflexivity is one of the core criteria which must be present in effective Critical Realist research. Further, the authors state that during evidence collection, participants should feel able to freely question, disagree, and express themselves and that these perspectives should be assessed on their credibility. Thus, several conversations were held with participants prior to evidence collection to assess their suitability for this research. A full-breakdown of the ethical considerations is provided in Section 4.5.

4.2. Interviewee selection and recruitment

Section 4.2 details the approaches to interviewee selection and recruitment taken in this research. The first subsection outlines the criteria required to participate in this PhD. The second subsection explains the channels of recruitment of potential research participants and also details the documentation which was provided to each participant, prior to their involvement. The final subsection provides a breakdown of the interviewees who were involved in this study.

4.2.1. Criteria for participation

As stated by King et al. (2019), the philosophical assumptions being made in the study should inform the selection process being applied in research. Consistent with the critical realism being applied in this study, the criteria for being included in this research is guided around the research participants experience of real events (Archer et al. 1998). As a result, the criteriology for participation places emphasis on the potential participants experiences and knowledge of the phenomena being studied. Further, the assumptions of epistemological relativism dictate that knowledge is a product of social construction (Bhaskar, 1989). Thus, the quantity of data collected and the number of perspectives which inform the analysis must be large enough to facilitate data analysis of the external phenomenon without an overreliance on any single individual. However, it is also important to recognise that each interview participant cannot offer the same amount of value to the research due to their differing experiences and knowledge. Similarly, Cresswell & Plano Clark (2018) note that a purposive selection criteria should be used to select participants whom have extensive experience working with the studied phenomenon. As such, this study employs a purposive criterion for inclusion in this research. This selection approach prioritises the value that potential interviewees can add to the research according to their experiences working with blockchain technology in supply chains in order to identify and select “information-rich” participants (Patton, 2014, p53).

This research also uses a second approach to identify and select participants. In their work into blockchain barriers in supply chains, Treiblmaier et al., (2021) call for future research which captures various stakeholder perspectives which are not accounted for in their study. As a response to that study, this research employed a maximum variation selection criterion with regard to stakeholder position. In their study, they collected evidence from supply chain managers. In this study, preliminary discussions were conducted with individuals from industry prior to evidence collection. From these discussions, several stakeholder groups were identified which each play a different role in the deployment of a blockchain solution throughout a supply chain. As can be seen in Table 5, these were: (1) Deployment Leads: individuals at the organisation(s) which were seeking to deploy the blockchain throughout their supply chain, (2) Technology Providers - individuals which work at organisations which provide the blockchain and/ or supporting technologies, (3) Advisors - individuals whom work as consultants on the deployment of the blockchain technology to any of the involved organisations, and (4) Supply Chain Members – individuals who work at organisations within the supply chain who are being asked to allow the blockchain operate within their firm.

Table 5: Key stakeholder groups in this research project

Identified Key Stakeholder Group	Definition
Deployment Leads	Individuals at the organisation(s) which were seeking to deploy the blockchain throughout their supply chain.
Technology Providers	Individuals whom work at organisations which provide the blockchain and/ or supporting technologies.

Advisors	Individuals whom work as consultants on the deployment of the blockchain technology to any of the involved organisations. These individuals can be providing advice to any of the other involved organisations.
Supply Chain Members	Individuals who work at organisations within the supply chain who are being asked to allow the blockchain operate within their firm.

This research sought to capture each of the above perspectives as each role has their own interests and is involved in different capacities throughout the deployment. Each stakeholder group presented differing levels of difficulty to identify and recruit to participate in the research. The technology providers were the most accessible as all of their online presence was around providing blockchain solutions. The Advisors and Deployment Leads were equally difficult to identify as blockchain was not the focus of their online marketing as the focus was on the range of products/ services which they provide. Supply Chain Members were by far the hardest to identify as they tended to have little to no online presence and when they did, it was not stated if they were using a blockchain. Yin (2018) proposes that key informants can provide access to other participants which can overcome some issues when it is hard to identify participants from the desired population. Key informants from the other stakeholder groups who had participated in this research did make contact to see if any Supply Chain Members, who meet the participation criteria, would be willing to participate in this research. Unfortunately, none of the contacted potential participants desired to participate in the research. As a result, Supply Chain Members is a perspective which is not present in this research. Although, several interview participants do still provide the Supply Chain Member perspective second-hand where they deemed appropriate.

As shown in Table 6, there were four criteria in this research which the potential interviewees needed to meet in order to qualify to participate in this research, and an additional two criteria which were preferred but not required. One of the intended contributions of this research is that this study captures the perspectives of key stakeholder groups, to the blockchain deployment throughout the supply chain, which have previously

not been represented in the literature. CR1 is the criterion which ensures that this contribution can be made as it requires that the potential interviewee fits into one of the key stakeholder groups which were identified from the preliminary discussions with industry experts. CR2 is the criterion which ensures that the participant has the first-hand experiences required to provide insight into the studied phenomenon. CR3 ensures that the participant understands how their data will be used and that they give consent for it to be used in this way.

Lastly, CR4 is the final required criterion. CR4 states that it is required that the participant has experience working with a blockchain which was deployed throughout a supply chain. This research applies the definition of supply chain that is put forth by Mentzer *et al*., (2001).

> *[Supply Chain is] a set of three or more entities (organizations 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, p4)

Table 6: Criteria for participation in this research project

Criterion Reference	Criteria	Required/ Preferred
CR1	The participant must fit into the Deployment Lead, Technology Provider, Advisor, or Supply Chain Member categories to one or more blockchain solutions.	Required
CR2	The participant must have first-hand experience working to deploy and/ or scale a blockchain solution in some capacity.	Required

CR3	The participant agrees to be interviewed and other criteria within the consent form.	Required
CR4	The blockchain(s) that the participant has experience with is deployed in a supply chain, as defined by Mentzer et al., (2001).	Required
CR5	The blockchain was deployed at production grade	Preferred
CR6	The participant holds a management position.	Preferred

This definition was selected because it is broader than some more limiting definitions of supply chains as it includes the flow of services. Some of the authors from the study go on to release a subsequent paper where they discuss some of the definitions around supply chains and supply chain management. They explain how consumers trends have shifted so that renting products is now more prominent than it used to be (Min et al., 2019). Because of this, a broader definition was used to ensure that supply chains where products, infrastructure, and services were rented could be included in the study. This decision was made to increase the pool of possible cases which could be involved in this research, due to the infancy of blockchain technology being used in supply chains.

CR5 and CR6 are criteria which were preferred, but not required. As discussed in Section 3.3. Contributions to theory and industry, there are few projects which have gone to production grade which has meant that insights into production grade deployments are currently scarce in the literature. This criterion states that production grade deployments are preferred; however due to the limited number of available participants, deployments which reach POC or Pilot are also included in this study. CR6 states that interviewees with management experience are preferred. This is because it is assumed that if the individual held a senior position with regard to the blockchain project, then they will have generally had more decision-making power and more insight into the actual challenges which occurred throughout the deployment. Further, some information may have been restricted to certain levels of management which would make these individuals more favourable to interview. However, due to the limited number of available instances where blockchains have been deployed beyond a pilot, as well as the infancy of blockchain technology more generally, seniority is only preferred.

Lastly, participants were divided into two categories based on the quantity of experience which they had in deploying blockchains throughout supply chains. If a participant had one main project which they had worked on, then they were asked questions about that specific case. Alternatively, if participants had worked on several projects which meet the criteria, then they were asked questions more generally, drawing on their expertise from all of the cases which they had been a part of. This decision was made for three reasons: (1) Due to the limited number of publications which document the challenges of deploying blockchain throughout supply chains, having one set of participants answer questions based on their entire experiences was a means of capturing more generalisable barriers and themes which could then be coupled with the in-depth particularisation of the cases. (2) Practically, it was difficult to discern which case would be the best to discuss in an interview given that the majority of the interviewees who gave general interviews also held senior positions and had less time to dedicate to the research. And (3) some participants did not want to discuss particular cases they had worked on, even without needing to name organisations, due to non-disclosure agreements, but they were willing to discuss the barriers and solutions they employed in a more general sense.

4.2.2. Recruiting participants

Two main channels were used to identify and recruit participants to be involved in this research project and they are clearly detailed in the remainder of this section. All of these approaches were sensitive to GDPR and were consistent with the ethics application which corresponds to this research which aims to reduce potential harm to participants and prospective participants. Further information about the ethical considerations is provided in Section 4.5.

The first channel which was used to identify and recruit participants was to recruit participants through the Grantham Centre for Sustainable Futures network, which aided in the funding of this research project. The Grantham Centre is a sustainability focused organisation based at The University of Sheffield which aims to aid in the realisation of a sustainable future. They aim to enact this in a multidisciplinary manor which combines academia, industry, and policy. Within the Grantham Centre there are Grantham Ambassadors who are individuals with highly regarded expertise in their respective fields and industries. In this research project, Grantham Ambassadors which have expertise in blockchain, management accounting, and supply chains acted as gatekeepers who could provide introductions to relevant individuals. All of the preliminary discussions, which were held to aid in the development of this research project, were held with participants recruited through this channel.

The second channel which was used to identify and recruit participants was through social media. Specifically, three social media platforms were used to select and recruit interviewees – (1) LinkedIn, (2) Discord, and (3) Slack. LinkedIn is a social networking platform which is designed to allow users to create a digital identity which they can use to then build and engage with their professional networks. LinkedIn offers a search functionality which allows the user to search for specific keywords and then the platform will display results which pertain to the keyword. A variety of keywords were used as search inputs to identify potential participants, such as 'blockchain', 'supply chain digitalisation' and 'blockchain supply chains'. This can then be filtered in several ways which allowed for the identification of individuals which work in a variety of different key stakeholder groups – consistent with the maximum variation selection approach detailed in Table 5. LinkedIn also offers optional permissions to each user which allow them to reveal information about themselves which they wish to share. As a result, every participant in the research only shared information which they wished to disclose to the public. The platform allowed for the identification of individuals who work with blockchain, and also includes information about them such as their current employer and their job titles. If a cursory look at an individual's profile indicates that the individual may meet the criteria, in Table 6, then they were contacted using the messaging feature on the application. This initial contact is used to gauge the suitability of the potential participant as it is not always clear from their profile if

they meet all criteria to participate. Alternatively, some communities have servers on social platforms such as Discord and Slack. For instance, several popular blockchain platforms have Discord communities of developers and blockchain stakeholders, and there are numerous regional slack servers for people with blockchain interests from different areas. The research was advertised to these communities through these platforms and potential participants would then reach out if they wanted further information about participating. Thus, the initial contact was led by the potential participant when using Discord/ Slack, unlike when using LinkedIn.

Following this initial contact, the participant was provided with the information sheet and consent form and then the participant can evaluate if they wish to be involved in the research. In the majority of instances, a short 15-minute chat was scheduled, using Microsoft Teams or Google Meet, to discuss the prospect of an interview and to afford the participant the opportunity to ask any questions which they may have; however, in some instances, the communication was conducted through a series of messages and/ or emails. Overall, of the 18 participants involved in this research, one was recruited through Discord, two were recruited through Slack, and 15 were recruited through LinkedIn.

4.2.3. Interviewee breakdown

Table 7 details each of the interview participants alongside their years of blockchain experience and their relevant experience to this research. Participant aliases are formatted as “Interview Participant” followed by the number that they were interviewed in chronologically. On occasion an abridged version of this that is sometimes used in the remainder of the document is “IP” followed by their participant number, eg IP01 for Interview Participant 01. The table also details if the participant was interviewed on one

specific case, or on their experiences more generally. Relevant experience is defined as any occupation which relates to participation criteria in Table 6. Lastly, the years of blockchain experience is dated to the time of evidence collection.

Given the advent of Bitcoin in 2008 first proving the technology for cryptocurrencies (Nakamoto, 2008), and popular platforms such as Ethereum and Hyperledger launching in 2015 enabling greater enterprise blockchain functionality; there is only a short window for individuals to have been working with the technology prior to evidence collection. Despite this, the interviewees within this research have a large amount of first-hand experience working with blockchain technology relative to the infancy of the technology. The levels of experience working with blockchain technology vary between each of the participants. However, all of the participants have at least three years of experience working with blockchain technology. Further, some of the individuals have over eight years of experience working with blockchain technology. This is significant as currently the quantity of interview research where the interviewees have first-hand experience working with blockchain technology is limited in the extant literature. In instances where an interviewee has held numerous roles where they have gained relevant experience, a subjective assessment was made about which role was most relevant to this research.

Table 7: The relevant experience of the interviewees

Interviewee Profile		**Relevant experience**			
Interview Participant Number	**Case/ General**	**Blockchain Experience**	**Management Level**	**Organisation Type**	**Organisation Size**
01	Case	3+ years	Middle management	Technology Provider	10-49 Employees

02	General	5+ years	Upper management	Technology Provider	250+ Employees
03	Case	3+ years	Middle management	Technology Provider	10-49 Employees
04	Case	6+ years	Middle management	Deployment lead	250+ Employees
05	General	6+ years	Upper management	Technology provider	10-49 Employees
06	General	4+ years	Upper management	Technology provider	10-49 Employees
07	Case	4+ years	Middle management	Deployment lead	250+ Employees
08	General	6+ years	Middle management	Technology provider/ Advisor	250+ Employees
09	General	6+ years	Upper management	Advisor	Under 10 Employees
10	General	6+ years	Upper management	Advisor	10-49 Employees
11a	General	7+ years	Upper management	Advisor	Under 10 Employees
11b	General	4+ years	Upper management	Technology provider	Under 10 Employees
12	General	5+ years	Upper management	Technology provider	10-49 Employees
13	Case	5+ years	Upper management	Deployment lead	250+ Employees
14	General	8+ years	Upper management	Technology provider	Under 10 Employees

15	General	5+ years	Lower management	Technology provider/ Advisor	250+ Employees
16	General	8+ years	Upper management	Technology provider	250+ Employees
17	General	5+ years	Lower management	Technology provider	250+ Employees

The majority of the interviewees in this study work as Technology Providers. This can largely be attributed to issues detailed in Section 4.2.1 around the accessibility of different stakeholder groups. However, it is important to note that there is a large amount of crossover between each of these stakeholder positions as can be evidenced in the interview transcripts. The Technology Providers often acted as Advisors to the Deployment Leads and Supply Chain Members. Additionally, in situations where consortiums were formed for the deployment of the blockchain system, Technology Providers and Advisors can operate within the consortium as Deployment Leads. Also, depending on how closely the Advisors and Deployment Leads operated, they could be considered as the same entity for that specific project. Thus, a large amount of the participants have worked in several of the stakeholder roles and this varies from project-to-project. However, the primary role of the participant is listed within the table.

Organisation for Economic Co-operation and Development (OECD) data was used to classify each organisation according to size by using the number of employees within that organisation (OECD, 2024). The information for this data was taken from a variety of outlets in the public domain and should only be considered as a guideline. As a result, organisations with fewer than 10 employees are considered micro enterprises, organisations with 10-49 employees are considered small enterprises, organisations with 50-249 employees are considered medium enterprises, and organisations with over 250 employees are considered large enterprises. The interviewees in this research work in organisations of a variety of different sizes. This is important as some research suggests that the barriers to blockchain deployment can vary according to the size of organisation as this impacts the available resources and the level of influence throughout the supply chain (Treiblmaier et al., 2021).

The participants within this research come from organisations of various sizes, meaning that if factors such as organisational resources and influence emerged as being significant then this would be evidenced in the data analysis.

All participants in this research met criterion of having held a management position in relation to blockchain technology. There are a variety of different management positions present in this research with some participants in lower management, some in middle management, and the majority having held upper management positions throughout their careers. Additionally, of the participants who have held upper management positions, some have held these in smaller enterprises whilst others have held these in large enterprises. This is valuable as when coupled with the years of experience with blockchain technology, and the various key stakeholder roles within this research, the interviewees within this study are highly valuable research participants which enabled the collection of information-rich evidence (Patton, 2014).

4.3. Evidence collection

The evidence collection method being applied in this research is semi-structured interviews due to the epistemological assumptions being made in this research project. Section 4.3. is structured so that it is divided into three contingent parts. (1) The chosen method for evidence collection is detailed alongside the rationale. (2) The specifics of the interview schedule are detailed and linked back to the philosophical assumptions. Lastly, (3) additional considerations for how the interviews were conducted are explained.

4.3.1. Rationale behind using semi-structured interviews

The evidence was collected through a series of interviews with participants who meet the criteria which was detailed in Table 6. Interviews were selected as the most appropriate method for evidence collection for 3 reasons. (1) Interviews can be conducted in ways which

allow the themes within the cases and between the cases to emerge. This is crucial given the limited quantity of emergent research into barriers to blockchain deployment throughout supply chains. As a result, it is necessary to use an evidence collection method that allows for unexpected results to be explored (Lee & Saunders, 2017). (2) Consistent with the critical realism being applied in this study, the evidence collection needs to permit insight into social constructions whilst being able to facilitate the generation of competing explanations of events (Bhaskar, 1989; Easton, 2010). And (3) interviews are a flexible method which can be conducted remotely, using various mediums, and with varying numbers of participants (Saunders et al., 2023). As evidenced in Appendix B, Covid-19 impact form, the Coronavirus-19 pandemic meant that any research method which was applied must be flexible and methods which could be conducted remotely were more favourable during the period when evidence was collected.

Semi-structured interviews were identified as being the most appropriate type of interviews in this research study. This was because they provide a structure for the interviews which is a valued trait of the method, given the relative inexperience of the researcher with interviewing prior to this research project, whilst still allowing for an exploratory component. This is an advantage of semi-structured interviews over unstructured interviews as Strauss & Corbin (2008) note how unstructured interviews require extensive experience by the researcher in order to realise their exploratory benefits. Conversely, semi-structured interviews were deemed more appropriate than structured interviews because, unlike structured interviews, they more readily permit an emergent component (Saunders et al., 2023). Lastly, group interviews were included as a type of interview within this study. Llewellyn (2008) states how in times of change, group interviews can be a valuable tool for capturing understanding between individuals through debate and social interaction. The deployment of a blockchain throughout a supply chain is a time of change and uncertainty for the individuals who work on building the blockchain and for individuals who have to develop news was of working and interacting with the blockchain. Throughout the evidence collection, only one group interview was conducted due to difficulties in accessing collectives of individuals.

4.3.2. Interview Schedule

Participants were divided into two categories – (1) Case Specific interviews and (2) General interviews. The categories denoted the type of interview which would be conducted. If the individual had worked on several blockchain projects then they would be asked questions which were phrased generally and placed the main themes and concepts as the unit of analysis. Alternatively, if the participant had worked on one blockchain project, or if they could discuss one specific project in greater detail, then they were asked questions about that specific case in order to elicit a greater level of particularisation. Further, because of the greater level of detail that was placed on the contextual factors of that case, this allowed for more contextual factors to be considered in relation to the research phenomena. The main differences between the two types of interview were: (1) The level of detail placed on context was greater and more specific in the case interviews. (2) The questions were phrased generally in the general interviews and were phrased specific to the case in the case interviews. Other than this, the interview schedules were very similar. For the remainder of this section, unless stated otherwise, extracts are included from the general interview schedule as the majority of the interviews fell into this category. The General Interview Schedule is included in Appendix C, and the Case Interview Schedule is included in Appendix D.

Patton (2014) proposes that in qualitative research there are six types of interview questions and that each of these different types of interview questions will elicit a different type of information. In this study, only five of Patton's (2014) types of interview questions were utilised in this research as sensory questions were not considered relevant to the research questions. Patton's (2014) six different types of interview questions are included in Table 8, alongside an adapted and shortened definition.

The interview questions within the interview schedule were structured using a key-point format. However, the interview questions were originally formatted in a full-question format. During reflective memo writing of the first interview, it was noted that a key-point format would make the interview schedule more readable when adding notes during the interview as reading larger sections of writing could have compromised the rapport

between interviewer and interviewee. As a result, the interview schedule was adjusted to a key-point format where each question had several suggested probes underneath, which each had their own spacing for notes to be added. This allowed for a better management of the interview as the schedule was formatted in a way which was clearer and more readily understandable upon a quick glance.

Table 8: The different types of interview question - Derived from Patton (2014)

Type of interview question	Definition in this study
Background questions	Descriptive questions that seek to understand the characteristics of the interview participant
Experiential questions	Questions which seek to understand the historical actions of the individual or of a collective
Opinion/ values questions	Questions which seek to understand the participants views on the research topics
Feeling questions	Questions which seek to understand specifically how an individual felt at the time of a specific event
Knowledge questions	Questions which seek to understand an interview participants subjective belief of what they believe is true.
Sensory questions	Questions which seek to understand a participant's recollection of their senses at the time of an event.

Lastly, the interview schedule questions were formulated in accordance with certain principles to remain consistent with the philosophical assumptions and the quality assurance checks within this research. Firstly, the underlying assumption of questions are considered to ensure that the question is not phrased in a way which would imply or convey

any predisposition that could influence the respondent. This is necessary as Yin (2018) notes that in some instances interview participants can respond how they believe the interviewer wants them to, rather than providing an honest account, and as a result it is the researcher's role to ask questions in a way which minimise the researchers influence over the interviewees responses. To mitigate the possibility of this, interview questions were phrased so that they are not leading and do not presuppose an outcome.

Another consideration when designing the interview questions was to try and ensure that the questions are not over-complicated and difficult to understand. This is achieved by only asking one question at a time (Rubin & Rubin, 2012), rather than bombarding the participant with several sub-questions at once, and by keeping the questions as simple and clear as possible in the interview schedule (Brinkmann & Kvale, 2015). The objective of the aforementioned strategies is to ensure that the interview questions are designed to elicit the most insightful responses around the research topic as possible. The remainder of this section details the specifics of the interview schedule.

The remainder of Section 4.3.2. Interview schedule is divided into three sections which each reflect one of the three sections on the Interview Schedule. Section 4.3.2.1. explains 'The open' of the Interview Schedule. Section 4.3.2.2. covers The Body of the Interview Schedule. Lastly, Section 4.3.2.3. outlines The Close, the final section of the Interview Schedule. As can be evidenced in Appendix C and Appendix D, probes were planned and utilised throughout all sections of the Interview Schedule to elicit further information throughout the interview. However, the discussion and underpinning rational for the probes are only included in section 4.3.2.2. Interview schedule – The Body, as this is where the majority of the probes feature. Throughout each of the subsections, excerpts from the interview schedule are included to provide context and evidence to support the discussion.

4.3.2.1. Interview Schedule – The Open

The open is primarily concerned with what Patton (2015) defines as background questions used in conjunction with other general housekeeping questions and statements. Consistent

with this, there were three primary objectives of the open in this research study. (1) It was confirmed that the participant understands the research and their prospective role. (2) Rapport was built with the participant and questions were pitched at a more accessible level to facilitate this. (3) Background information was attained which was used to frame, and provide context to, the subsequent discussion in the body of the interview schedule. The open started with general housekeeping points. These include setting expectations of the research participant, explaining the research objective, and clarifying that they consent to the points detailed in the consent form. Following this, the recording was started and emphasis was then placed on background questions. Rubin & Rubin (2012) note how using questions which are designed to easy to answer and attain a descriptive account of events can also aid in settling the interview participant. The background questions being utilised in this research study can be divided into two sections. The first aims to attain knowledge about the participant and their experience and the second aims to acquire knowledge about the blockchain projects that they have been involved with. This can be evidenced in Figure 2. Patton (2014) explains how it is often easier to talk about ones lived experience, and as a result this question preludes the second type of background question used in this research.

1) Can you provide me some **background information** on yourself and your **experience** please?
    a. Time working with blockchain
        i.
    b. Role
        i.
2) Can you tell me a little bit about the **types of blockchain projects** that you have worked on?
    a. So, things like the **objective** of different DLTs (tracking, leasing, etc), and the various **scopes** of the projects, **accompanying technologies** etc
        i.
    b. Sector and solution types
        i.

Figure 2: Extract from the open, taken from the general interview schedule (Appendix C)

As can be seen in the extract from the case specific interview schedule (Figure 3), the background questions were more specific and elicited a greater level of depth into contextual factors than in the general interview schedule. The purpose was to use background questions to build a descriptive outline of the case by asking questions which were easy for the participant to answer (Castillo-Montoya, 2016) and were asking about the participants lived experiences (Patton, 2014). Each is accompanied with some planned probes which were only used if the participants responses did not provide sufficient information on that aspects. Thus, different probes were used with different interviewees according to their responses.

1) Can you tell me a little bit of background on the _____ blockchain?
    a. What did the blockchain do (objective)?
        i.
    b. Who was working on the project? Were parts outsourced?
        i.
    c. Who was funding the project?
        i.
    d. Who were the stakeholders of the project?
        i.
    e. What is the end goal of the project?
        i.
    f. What state is the project in currently?
        i.
2) Can you tell me a little bit about your **role** in relation to the _____ project?
    a. Day to day?
        i.
    b. Responsibility?
        i.
    c. Who did you have contact with?
        i.

Figure 3: Extract from The Open, taken from the case specific interview schedule (Appendix D)

One important consideration which was made was around the time which was allotted to the interview. In some instances, the interviewees had been able to commit over an hour to being interviewed, whilst some others had only been able to commit half an hour. Consequently, sometimes the decision was made to skip over some probes in order to allow more time to discuss more central topics in greater depth later during the interview. For example, Interview Participant 13 had only been able to schedule half-an-hour for an

interview, and he was delayed in joining the interview. As a result, he joined the interview with only 20 minutes remaining on the allocated time. Thus, the decision was made to skip over some of the contextual probes within the open, in order to spend more time discussing the questions in the body of the interview schedule. These considerations are detailed in the Reflexive memos made after each interview (Appendix E).

4.3.2.2. Interview Schedule – The Body

The body of the interview schedule is the largest section in the interview schedule as it is the most fundamental section to the research question and features the most targeted questions that are closest to the core research question (Castillo-Montoya, 2016). Within the body of the interview schedule, questions were designed so that they were open-ended so that they facilitate the collection of exploratory knowledge (Patton, 2014). The questions began generally, before increasing in specificity (Rowley, 2012). Consistent with the emergent approach being utilised in this research, this afforded the participant the opportunity to organically bring forth whatever they deemed relevant to the research question and notably, this is where the main themes from this research were identified as several participants brought forward similar issues without prompting. These would then be explored and as a result, the interview questions were not proposed in the same order, or the same way, between interviews as a receptive approach was taken to the research situation (Lee & Saunders, 2017).

As stated previously, one difference between the two interview schedules is that in the general interview schedule the questions are phrased generally whilst in the case interview schedules the questions are specific to the case being discussed. Thus, in the general interview schedule the majority of the questions are knowledge seeking questions as the key themes are central to the discussion. Alternatively, in the specific case interview schedule, there is a greater emphasis on experiential questions, due to the difference in phrasing (Patton, 2014). The questions in the body of the interview schedule are logically consistent with the epistemological assumptions being made in this research project.

Table 9: Main interview questions within the body of the general interview schedule alongside their respective question types (Patton, 2014)

Interview Question (In full-text format)	Type of Interview Question	Question Reference
Is there a general series of phases, that the implementation and scaling of a blockchain throughout a supply chain generally goes through?	Experiential/ Knowledge	Body-01
What are the most frequent challenges which blockchain projects in supply chains generally run into when implementing and/ or scaling?	Knowledge	Body-02
What are the challenges which, when they occur, can be the most derailing to the deployment and/ or scaling of a blockchain project in a supply chain? Resulting in the project getting scrapped or just severely disrupting the process.	Knowledge	Body-03
Are there any other types of problems which supply chain blockchain projects face which we you would like to mention, and if so, why are these important?	Knowledge	Body-04
What general strategies/ approaches/ resources can organisations have/ or employ to minimise these disruptions?	Knowledge/ Experiential	Body-05
How has your own thinking on these enterprise DLT projects evolved over time and how will you approach these situations in the future?	Opinion/ Values	Body-06

Building on the discussion included in Section 4.3.2., Table 9 shows the questions included in the body of the interview schedule alongside their respective type of interview question, as described by Patton (2014). These are presented in a full-text format for the purposes of auditability within this report; however, in the interview schedule these were formatted in a key-point format so that the interview schedule was easier to follow when conducting the interview. The majority of the main interview questions are knowledge and/ or experiential questions which are designed to elicit compartmentalised understanding of the research question (Roberts, 2020). All of the questions within the body of the interview schedule are broad and open-ended. This ensures that the interviewee can organically bring up information which they deem important to the research question (DiCicco-Bloom & Crabtree, 2006). This is necessary as it is consistent with the intended contributions of this research as this enables emergent evidence collection; addressing a limitation within the extant literature.

One important note is that the interview questions and the corresponding probes are occasionally designed to capture a different type of knowledge. For example, interview question Body-02 is a knowledge question. However, that does not mean that all of the corresponding probes will be phrased as knowledge seeking questions. For example, Figure 4 shows an excerpt of a probe from the interview with Interview Participant 02. Whilst the initial question was a knowledge seeking question, the probe which was used was an experiential seeking question which sought to provide context to the points made from the interviewee's response, about supply chain members purposefully creating legal hurdles, to the initial question. Thus, just because the initial interview question is pitched at a certain level, the probes are then used to attain a greater depth of knowledge and explore this concept from different perspectives, with the objective of building a more holistic data set for analysis.

When a company is trying to throw in legal hurdles, in your experience what would you say has been the reason for why they would want to do that?

Figure 4: Excerpt from interview with Interview Participant 02 showing an example probe which was used

The probes detailed in the interview schedule can be considered into three distinct categories. King et al. (2019) propose that there are three types of probe. The first is elaboration probes. Elaboration probes in this research are probes which aim to elicit further information on the research topic. The second type of probes are clarification probes. Clarification probes are used to verify understanding of something the research participant has said. One issue, the authors note, with using clarification probes is that when used incorrectly they can undermine the researcher's competence in the eyes of the participant (King et al., 2019). To mitigate this, clarification probes were prioritised to focus on the most substantial aspects of their responses, rather than specific words or phrases. The third type of probe being used in this research was completion probes. Completion probes are used to allow for the participant to finish something which they were saying earlier in the interview. Completion probes proved especially valuable when interviewing participants whose responses included lots of tangential points, as this provided a means of steering the conversation to remain on the research topic (Rubin & Rubin, 2012). In the interview schedule, each key-point question is accompanied with a range of probes which acted as a checklist for each question (Cassell, 2015). Thus, as can be seen in Figure 5, a checklist of predominantly knowledge probes were included as these probes were developed from the extant literature. Consistent with the key-point format, each of the probes were bulleted under their corresponding question. Probes were then pitched to the interviewee as elaboration, clarification, or completion probes in order to respond to the discussion the interview. Additional probes that were not anticipated within the interview schedule were asked throughout the interview where appropriate (McIntosh & Morse, 2015). Again, this was done in order to facilitate the emergent approach been taken in this research.

2) What are the most frequent challenges which blockchain projects in supply chains generally run into when implementing and/ or scaling? (Knowledge)
    a. Organisational
        i. Financial constraints, management support, understanding of DLT/ ease of use, stakeholders, existing IT department/ resources, unknown ROI
            1.
            2.
            3.
    b. Technological
        i. Data collection issues, hardware/ software issues, immutability challenges, integration issues, scalability issues, security issues, sustainability/ energy
            1.
            2.
            3.
    c. Supply Chain/ External
        i. Governmental policy, lack of industry examples, market competition, challenges onboarding supply chain, Collaboratory challenges, cultural difference, data and information transparency issues
            1.
            2.
            3.

Figure 5: Excerpt from the general interview schedule showing the corresponding listed probes

If these probes kept occurring between interviews, they were then added to the interview schedule so that they could be discussed in subsequent interviews with other participants where appropriate. The best example of this was how in the first interview in this study there were only three listed probes for Body-02. However, by the last interview conducted in this study there were over 20 probes listed for Body-02. Additionally, each of the probes were used where needed. As a result, not all probes included in the interview schedule were used for each interview question as the relevance of each probe was understood by listening to the initial answers the participant provided to the interview question (Jacob & Furgerson, 2012). This approach was taken to ensure that the responses from the other interviewees, and the findings from the extant literature, were not thrust upon the interview participants and could not influence their responses by the interviewee responding by saying what they think the researcher wants to hear (Saunders et al., 2023).

4.3.2.3. Interview Schedule – The Close

Finally, the last section in the interview schedule is the close. This is the shortest of the three sections and there are three objectives of this section which each correspond to a different question/ statement within the close. The first objective is to clarify any responses of the participant which may have been misunderstood. The purpose here is to ensure that the data set accurately reflects and captures the perspective of the participant. In practice the opportunity to clarify the responses of the participants was rarely utilised within this portion of the interview. Instead, clarification was predominantly done during the main body of the interview at the point at which the participant made the point which needed clarification. This was achieved in numerous ways; however, one frequently used approach was by repeating the participants' points back to them in a summarised form in order to verify they agree with what was understood (Rubin & Rubin, 2012). The second objective is to aid in the recruitment within this research project. Specifically, the participants were asked if they could contact any of the individuals that they had either directly, or indirectly, mentioned in this study, and see if they would be interested in participating in the research

project as well. Four of the participants were recruited as a result of this approach. The final objective was to thank the participant for their involvement in the research project.

4.3.3. Conduct of the interview

The purpose of this section is to detail the specifics of how the interviews were conducted, as well as explaining the underpinning rationale behind the decisions made.

4.3.3.1. Interview platform and medium

The interviews were all conducted online using various video conferencing platforms. The majority of the interviews were conducted using Google Meet; however, some interviews were conducted through Microsoft Teams and Zoom as some participants were unable to access specific video conferencing platforms. The decision to use an online medium was made for two reasons: (1) The Government guidelines in the UK which were put in place in response to the Coronavirus-19 pandemic have changed several times throughout the course of this PhD. Thus, it was not feasible to plan for face-to-face interviews given the uncertainty in future policy. (2) The interview participants involved in this research were from a variety of different countries. As a result, online interviews offered a greater degree of flexibility and increased the accessibility of participants who would otherwise be extremely difficult to meet with. Online video conferencing platforms were preferred to telephone interviews because they more readily simulate the face-to-face interview as the interviewee and interviewer can see each other, which some authors suggest can allow for a greater degree of rapport to be achieved (Deakin & Wakefield, 2014). As a result of the decision to conduct online video call interviews with interview participants from across the globe, there was a need to be sensitive to potential time differences. To mitigate this, all interviews were conducted at times that were suited to the interview participants.

4.3.3.2. Audio recording considerations

The decision was made to record the audio from the interviews as this would allow for the most 'accurate rendition' of the evidence which was collected and the subsequent analysis could be a more accurate reflection of the collected evidence (Yin, 2018, p118). However, the audio recording was purely for use at the data analysis phase and was not a substitute for note taking or listening (Lee & Saunders, 2017; Yin, 2018a). The interviews were recorded and the interview participants each consented to this verbally or by signing the consent form prior to the interview. In some instances, the participant wanted to fill in the consent form after the interview as they were on a tight schedule and thought it would make more sense to use the time doing the interview and then they could formally consent when they had more time. In all of these cases, the participant had been presented with the information sheet and consent form prior to interview and the contents of the consent form and information sheet had been discussed with the participant prior to any recording. The interviews were recorded on two separate devices to mitigate the risk of any single device failing. One device was a dedicated recording device, whilst the other was a multimedia device which had voice memo functionality. Both of the devices were tested prior to each interview to ensure that they were working as intended. The recordings were started following a friendly discourse at the outset of each interview and all participants were made aware of when the recording device was being activated; as can be evidenced at the start of the interview schedule in Appendix C and Appendix D. During several of the interviews, the interview participant would ask to provide some 'off-the-record' information. This was not planned for before the first preliminary discussion, but during that discussion the participant wanted to state some information which they wanted off the record. As a result, in subsequent interviews this was planned for as if an interview participant stated something off-the-record, the recording device was left on, however, the excerpt that was off-the-record was not transcribed into the written accounts of the interview. Thus, when the audio recording was destroyed, the off the record evidence was also destroyed. The policy for off-the-record information was explained to each participant before the interview and each participant agreed to the approach.

4.3.3.3. Note Taking

One other adaptation of the interview schedule came as a result of the reflexive memo writing (Appendix E) which was carried out after each interview. Following the first two interviews it was noted that the interview schedule was difficult to follow as the note taking cluttered the interview schedule making it difficult to follow without compromising on listening to the interviewee which Lee and Saunders (2017) point out is one of the interviewer's main responsibilities. Thus, the interview schedule was reformatted, to the version seen in Appendix C and Appendix D, to ensure that there was more space for note taking and that the notes sections had some structure which would increase the readability of the interview schedule.

4.3.3.4. Building Rapport with the Interviewees

In this research, at the outset of the interview and from the prior contact, the objective was to build rapport with the interviewee. King et al. (2017) explain how building rapport is about building trust, and not about trying to be liked by the participant. This is because this can exacerbate the interviewers bias and can result in the interviewer influencing the interviewee's responses. This is of particular concern given the axiological implications of the limited realist philosophy being applied in this study. As detailed in Section 4.1.3. Axiological implications, minimising the impact of researcher bias is of great importance in order to add credibility to the findings by ensuring the impact of biases is kept to a realistic minimum. Several steps were taken to ensure that rapport was built with the interview participant. Firstly, as was detailed in Section 4.3.2. Interview Schedule, the interviews were designed to begin with simple questions, which would increase in complexity over the course of the interview as this type of approach can aid In settling the interviewee (Rowley, 2012). Secondly, as was mentioned in Section 4.3.3.1. the interviews were conducted remotely, but using a video conferencing platform instead of a telephone interview. This simulates some aspects of the face-to-face interview whilst also having the benefit of the

interviewee always being in a location where they feel comfortable and which does not disrupt their regular work patterns (Gray et al., 2020).

4.4. Data Analysis

The data analysis method being applied in this study is Template Analysis. The data analysis discussion is structured into two parts. The first part explains the rationale behind selecting Template Analysis as the most appropriate data analysis method. Meanwhile, the second section specifies the Template Analysis process. The second section is split into five subsections which chronologically detail the procedures which were taken throughout the data analysis.

4.4.1. Template Analysis rationale

Template Analysis was identified as the most appropriate data analysis method for this research. The form of Template Analysis within this research leans heavily on several key contributions and publications made about the method (Crabtree & Miller, 1999; King, 1998, 2004; King & Brooks, 2017; King, et al, 2018). Template Analysis is a form of Thematic Analysis (King, 1998, 2004; King & Brooks, 2017). Thematic Analysis approaches are defined by the combination of "defining themes that categorize significant features of the data" and organizing said themes into structures which demonstrate the relationships between themes (King & Brooks, 2017, p4). Template Analysis was selected as the most suited data analysis method for three reasons: Firstly, the data analysis method being applied in this study needed to be accommodating of the philosophical assumptions being made in this research. This criterion meant that approaches, such as Grounded Theory, could not be considered as they prescribe a strict philosophical and procedural approach to the research methods (Corbin & Strauss, 1990; Glaser, 1988; Glaser & Strauss, 1967; Strauss & Corbin, 1997). Secondly, one of the anticipated contributions within this research is the need for emergent research which does not holistically prescribe the extant literature upon the

collected evidence. Similarly, the evidence collection method needed to facilitate the collection of evidence remotely due to the globalised nature of the participants and potential restrictions of movement as a consequence of the Coronavirus-19 pandemic. As a result, semi-structured interviews were identified as the preferred evidence collection method. Consequently, any data analysis method needed to be compatible with analysis of interview evidence. Lastly, several publications researching the barriers to blockchains in supply chains had developed a list of barriers as themes, as their research outcomes. However, some of these studies were conceptual (Clohessy, et al., 2020; Saberi et al., 2019), or did not allow for these themes to be developed emergently from the evidence collection (Clohessy & Acton, 2019), or were limited in that they did not include production grade deployments, or focused on a specific type of barrier (Treiblmaier et al., 2021; Van Hoek, 2019). Consequently, the decision was made to use these highly relevant studies to develop some a priori codes which could be used as a starting point for the data analysis. Thus, a data analysis method that allowed for the inclusion of *a priori* codes was preferred for this research. A full discussion on a priori codes is provided in section 4.4.2.2.

One criticism levied at Thematic Analysis is that it can lead to a fragmented data set that does not provide holistic insight (King et al., 2018). In order to avoid this, following each interview a short reflexive memo was recorded to summarise the interview as a whole and to make notes. In line with the recommendations of King and Brooks (2017) these case summaries placed emphasis on the impressionistic, rather than the rationalistic coding process.

4.4.2. Template Analysis Process

The template analysis process is flexible and can vary between research projects (King, 2004). Thus, in the interest of transparency, it is necessary to detail the procedure clearly and accurately whilst also explaining the rationale which underpins these decisions (King and Brooks, 2017). The template analysis in this research project is adapted from the template analysis framework outlined in King and Brooks (2017) which is detailed in figure 6. This also informs the structure of the subsequent sections. Computer-assisted qualitative data analysis software (CAQDAS) was identified as the preferred medium for the analysis. This decision was made as there was a large quantity of evidence for analysis and CAQDAS has systems and tools which can aid in the management of large quantities of data. Whilst several programmes were considered, NVivo was identified as being the most suited CAQDAS given the researchers existing familiarity with the programme and that it can facilitate hierarchical coding which is needed in this research. As such, all of the data analysis discussed in Section 4.4.2.2. through to section 4.4.2.5. was conducted in NVivo.

4.4.2.1. Familiarisation with the evidence

The first stage of data analysis in this research project was familiarisation with the evidence. This starts with the transcribing process. Several procedures were conducted at this stage which increased the familiarity with the data. Firstly, the audio recordings of the interviews were transcribed using a denaturalised transcription approach. The rationale for employing this transcription approach in this research is that the spoken language may inhibit the understanding that can be gained from a clearer, grammatically sound, transcription (Bucholtz, 2000). This was deemed an important factor as some participants had English as an additional language and as such a full-verbatim transcription could allow for a misinterpretation of pauses and mumbles. Secondly, timecoding and speaker designations were added to the interview transcripts to increase the followability of the documents.

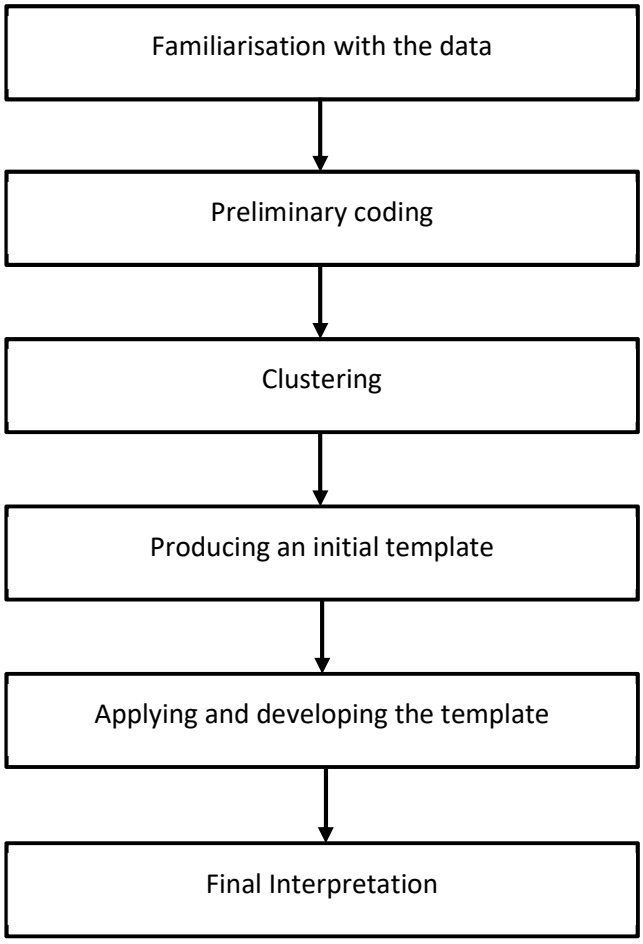

Figure 6: Template analysis process (Adapted from King and Brooks, 2017)

Thirdly, transcripts were read whilst listening to the audio file to check and amend any errors which were present from the initial transcription. Three codes were then applied to the transcript to depict any instances of (1) over-talking, (2) unclear audio, or (3) words of uncertainty. Lastly, the transcripts were proofread in order to verify their accuracy.

4.4.2.2. Preliminary coding and clustering

Following the evidence collection and the initial familiarisation through transcribing, the coding process began. The preliminary coding phase was comprised of three interconnected and iterative processes – (1) developing new codes through analysis of the data sets and

applying them to the data sets, (2) applying the a priori codes to the data sets (3) clustering the codes to show hierarchical and integrative relationships between the codes. Each aspect of the preliminary coding is detailed in this section. As all three processes in preliminary coding pertain to themes, it is first necessary to clearly define a theme. In this research a theme is defined the same as was defined by King and Horrocks (2010):

[Themes are] "recurrent and distinctive features of participants' accounts, characterising particular perceptions and/or experiences, which the researcher sees as relevant to the research question" (King and Horrocks, 2010, p150)

The initial process of developing codes through analysis of the data set was achieved through a combination of coding practices. The coding process in this study is adapted from the thematic analysis coding procedure described by King et al. (2019). Firstly, descriptive codes that describe sentences in the interview transcripts are developed. This is achieved by highlighting snippets from the transcript which seem valuable to the transcript. These include the participants "views, experiences, and perceptions" (King et al., 2019, p203). The descriptive codes stay close to the data and do not interpret underlying meaning or ascribe existing theory to the data. Parallel coding was a feature in this study. Parallel coding is where a single piece of data is coded more than once. At later stages of analysis, this allowed for that data to support more than one part of the template. In instances where parallel codes were used, attempts were made to develop more accurate codes that better explained the studied phenomenon, thereby condensing the parallel coded text into a single code. This was not always possible, but it was always attempted as a means of ensuring rigour in the data analysis process. Once the descriptive codes had emerged from the analysis of the first transcript, these descriptive codes were then applied to subsequent transcripts along with any new descriptive codes which explained the data.

As well as developing and applying new codes to the dataset, a priori codes which were developed from the literature review were also applied to the datasets where appropriate. The a priori codes in this research were 'soft' in that they were broader and loosely defined (King & Brooks, 2017). Several scholars have applied the TOE framework to blockchain

adoption in supply chains. The TOE framework seeks to explain technology adoption by categorising the factors into technology considerations, organisational considerations, and external considerations. In a conceptual paper, Saberi et al. (2019) produced a framework of barriers to the deployment of blockchains throughout supply chains which shared many similarities with the TOE framework but increased the specificity to this context. The authors recategorized the main four barriers as systems related, intra-organisational, inter-organisational, and external. This framework has subsequently been adapted and tested (Kouhizadeh et al., 2021; Treiblmaier et al., 2021). As a result, the codes within each category formed the initial *a priori* codes within this research. This was a relatively large number of *a priori* codes. However, consistent with the emergent approach, these codes were 'soft' and no attempt was made to fit the a priori codes onto the text (King & Brooks, 2017). Instead they were used in the early stages of analysis as a starting point. Throughout the data analysis process, most of these a priori codes were redefined, some were kept, and some were scrapped as they did not explain any of the collected evidence.

The next phase of coding the data set was interpretive coding. Interpretive coding has a greater level of abstraction than descriptive coding and aims to move beyond the descriptive data set. This occurs through interpretation of the descriptive codes in an attempt to capture the underlying meaning of said codes (King et al., 2019). The process of descriptive coding and interpretive coding is iterative and realisations at the interpretive stage can lead to adjustments of the descriptive codes. Once one data set has been coded, the newly developed interpretive codes and descriptive codes were then clustered into hierarchies showing connections between the different themes. This occurred in two ways: (1) Similar descriptive codes were clustered together and a new higher-level code was developed to categorise the lower level descriptive codes. And (2) the lower-level descriptive codes were clustered with higher-level interpretive codes. This was not fixed and many variations of the clusters were produced throughout the project. All of the codes and clusters were managed in NVivo and several alternative clusters were saved in their own files which were then reviewed and compared between each other. This iterative process of coding the data, clustering the codes, and adjusting the codes, continued as each new interview transcript was analysed - up until the development of the initial template.

4.4.2.3. Developing the initial template

In this research the initial template was developed after 12 of the transcripts had been analysed. More specifically, the majority of the general interview transcripts were analysed before the initial template was developed. The decision to develop the initial template after 12 transcripts were analysed was made for two reasons: (1) Because of the large number of *a priori* codes. This study included over 20 a priori codes. King & Brooks (2017) reason that when using a large number of *a priori* codes they should be used tentatively and that if the initial template is developed too early then you risk forcing the early codes onto the subsequent data. Thus, the decision was made to delay the development of the initial template to ensure that the codes within the template were not forced onto the data. (2) Because of the diverse responses. Whilst some of the participants gave similar responses; there were some areas which had only been mentioned by certain interviewees and some which were in direct conflict with one another. One example is of the difference between public and private blockchains. Not all participants had experience with both types of blockchain and as a result, they did not mention this as being a specific issue. However, some participants who had experience with both types of blockchains felt strongly that the different type of blockchains present different challenges and that one type of blockchain is far superior to the other. As a consequence of findings like this, the decision was made to delay the initial template until a larger quantity of data had been analysed.

The initial template was developed through a process of clustering and no limit was placed on the number of levels of hierarchical coding in order to allow for a greater depth within the themes (King & Brooks, 2017). In some cases, new codes were developed which categorised lower level codes; codes which were duplicates were merged into single codes; and codes were redefined to adjust the scope of the code. Integrative themes which show connections between sub themes and codes were not used in the initial template; however, some potential integrative themes were noted for future use as the template is adapted and reviewed. The initial template is still close to the text and more descriptive than the final template. In the initial template, higher level codes were aggregated from lower level codes. The initial template is included in Appendix F.

4.4.2.4. Applying and modifying the initial template

Once the initial template had been established through hierarchical clustering, the template was then applied to the datasets which had not yet been analysed, and to the datasets which had previously been analysed before the template was developed. Throughout this process, the template was modified to accommodate the new data and the previously coded data. The purpose was to ensure that the template accurately encapsulated the entirety of the datasets. King (2012) describes five types of modifications which can be made to the codes within the template; each of which were used in this research and they are presented in Table 10 alongside an additional type of reclassification which was also used in this research.

The body of work by Nigel King and his various collaborators on template analysis – of which heavily influence this data analysis – demonstrates that there are two antecedents to the final interpretation of the data set. The first is that the modification of the template must continue to a point where it "provides a rich and comprehensive representation" of the collected data (King and Brooks, 2017, Chapter 3, p12). At this point, the final template is developed. This is a subjective point that is denoted as being the optimal stopping point. It is worth noting one caveat of this is the possibility – or likelihood - that further analysis of the data could lead to new insights being made. Despite this, a point must always be identified in any research project as being the stopping point. In this research this occurred when each piece of data which was not coded was not deemed relevant to the research question and each piece of data which was coded fit into the template. The second requirement is that the final template must then be applied to the entire data set.

Table 10: Methods of Template Modification, adapted from Nigel King in Symon and Cassell (2012)

Method of Template Modification	**Definition**
Insertion	Adding new codes
Deletion	Deleting existing codes
Merging	Condensing several codes into fewer codes
Redefining	Adjusting the definition or scope of the code
Hierarchical reclassification	Moving themes 'up' or 'down' in the template
Integrative reclassification	Moving integrative themes across the template, reclassifying hierarchical themes into integrative themes, or reclassifying integrative themes into hierarchical themes

4.4.2.5. Final interpretation

Once the final template had been applied to the full dataset, the template was then analysed looking for patterns. These were identified by searching for patterns which can be categorised into four types: (1) Looking for themes that are highly relevant to the research question. (2) Looking for themes that are embedded in specific interviewee subsets that may not be present in other subsets of the collected data. (3) Looking for themes that affirm the predominant themes in the academic literature. (4) Looking for themes that challenge the predominant themes in academic literature – either through contradictory evidence or through an absence of prominence. The final template is presented in Section 5 Findings

and discussion and it is formatted as a linear list of themes and codes. The hierarchical structure of the final template is evidenced through the use of indentations. Where a code is indented further in than the code above it, this signifies that this code is a sub code within the hierarchical code. The themes identified from the final interpretation inform the structure of Section 5. The themes which are considered most paramount to the research question are sequentially presented along with verbatim quotations from the interview transcripts. Specific cases are spoken about individually where they effectively capture the themes from the overall data set. Themes at lower levels of the template are also be discussed; however, as these denote individual or infrequent instances, less emphasis is placed on these specific codes than on the macro level thematic trends. To avoid mass generalisation and to ensure particularisation of the cases is captured, short and long verbatim extracts of the interview transcripts are included in the discussion; along with extracts and summaries of the case summaries made immediately following the data collection. This is done to ensure that the cases and research question are discussed as the primary focus and that any limited generalisation only occurs where warranted.

4.5. Ethical Considerations

This research passed the University of Sheffield's internal ethics review on 22/06/2021. The ethical principle of minimising harm to all of the interviewees was upheld throughout this research and was achieved in several ways. A risk assessment of each phase throughout the research was completed. This risk assessment identified that the expected harm to the participants was 'inconvenience'. This is for four reasons which were derived from Yin (2018): (1) The participants were not asked personal questions; (2) The participants were not belonging to vulnerable groups such as children; (3) Actions were taken to ensure the confidentiality and privacy of the participating individuals; And (4) all participants provided consent to participate in the project. The remainder of this chapter is structured so that the ethical considerations made within this study are presented alongside the corresponding stages of the research process.

4.5.1. Design and access to interviewees

Saunders et al. (2023) note that there are different levels of consent a participant can give from inferred consent to informed consent. Informed consent is when a participant gives consent whilst having all of the required knowledge about the research and their role. Each of the participants have given their informed consent to participate in this research. This was achieved in several ways. Firstly, this was achieved by providing the potential interviewees with an information sheet. The information sheet covered an overview of the research, what is required of the participants to be involved in the study, detailing the potential interviewees rights, and explaining how their data will be used. The participants were also provided with several lines of contact to senior figures within the University of Sheffield which they can use to escalate any issues which they have. As well as the information sheet, participants were afforded the opportunity to ask any questions which they may have had. In some instances, this was done online – either on email or social media – and in some instances this was achieved through a short online video call. The short video call was preferred for three main reasons: (1) This allowed the opportunity to answer as many questions as the participant had and verify their understanding of certain points. This also acted as a means of being certain that the participant had a full understanding of what their involvement entailed and how their data would be used. (2) This short chat provided the opportunity to assess their suitability for the research, and to gauge which interview schedule was most appropriate. In some instances, it became evident that the potential participant would not be able to provide the insights which were needed for the research question. Thus, the short video call afforded the opportunity to verify the potential interviewee met the research criteria. And (3) rapport was built up quicker in the interview with the interviewees when there was a short video call prior to the interview. However, not all participants wanted the short video call. If the participant had not wanted to have a short video call prior to the interview, they were still always provided with the information sheet and always afforded the opportunity to ask any questions prior to an interview. Further, as can be evidenced in the Interview Schedules in Appendix C and Appendix D, the open of the interview included an outline of what their participation would require; clarified that they

had read the information sheet and consent form; and offered them a final opportunity to ask any questions prior to data collection.

4.5.2. Evidence collection and data analysis

Once the participants have provided consent, interviewees maintained the right to withdraw from the research at any point. However, any data which had been collected could not be redacted. Due to the interviewees giving informed consent, they were all aware of this in the consent form. However, no participants pulled out of the study after consenting. The axiological assumptions in this research acknowledge researcher subjectivity; however, where possible this subjectivity was recognised and actions were taken to minimise this. For example, as discussed in Section 4.3.3.2, the audio of each of the interviews was recorded. This allows for the most objective transcription of the interview evidence (Yin, 2018a), allowing for the subsequent analysis to be conducted on a data set which accurately reflects the views and statements of the interviewees. Further, all of the conditions within the consent form were upheld throughout the research process. This included steps such as anonymising all of the data, and taking care to not forward any personal details to other participants. Again, consistent with the axiological assumptions being made in this study, an audit trail was maintained to document the analysis process. This allows for external assessment of the integrity, accuracy, and approaches taken throughout the evidence collection and data analysis processes.

4.5.3. Data management

The research data and personal data within this research are in the form of audio files, interview transcripts, post interview reflections, spreadsheets, consent forms, calendar entries, and emails. As such, the following discussion pertains to all of the types of data previously disclosed. The following section explains how the data was organised, protected, and anonymised, as well as some other data protection considerations. The research is

consistent with the recommendations of the University of Sheffield's Policy on Good Research and Innovation Practices. This process ensures that the data management plan is at a level which is deemed satisfactory by the University of Sheffield. Throughout the research project, three principles were maintained for the management of research data – (1) confidentiality, (2) integrity, and (3) availability. The confidentiality principle requires that information is protected from those who are not authorised to access the data. In this research, the research team were the only individuals with access to the data. This included, the lead researcher, the primary supervisor, and the secondary supervisor. The integrity principle refers to the accuracy of the data. Thus, access to the raw interview transcripts will be maintained until three years after the publication of this PhD thesis. Lastly, the availability principle requires that the data is accessible to the research team when needed. The remainder of this section provides an overview of the data management processes in relation to the lifecycle of the data. Thus, the topics of data creation, storage, processing/ tools, sharing, archiving, and deletion are covered. The full data management plan can be viewed in Appendix G.

In this research personal data was created in several ways. Initially, data was in the form of calendar invitations and emails. In these instances, a University of Sheffield account was always used as the University have inbuilt safeguards to protect the confidentiality of the data. Following, a consent form was received which included the participants name, signature, and date, to show that they consent to participate in the research. If the document was a word document, then this was encrypted using the Microsoft Word in-built encryption. If this was a PDF, then no encryption could be placed on the file directly. Instead, the PDF files were compressed into a singular folder, and the compressed file was encrypted with a strong password. Then, research data was captured in the form of audio files, interview transcripts, and post interview reflections. In all of these cases, any data which could aid in the identification of the individual was obfuscated. In practice, this was predominantly the interviewees name, organisation names, and governments. Data was not anonymised when the interviewee was giving hypothetical examples; however, in instances of uncertainty, caution was exercised as the data was anonymised to prevent prospective readers from being able to identify the participant. One spreadsheet was created which contained the original names of the interviewees along with their respective unique

identifiers. This file was directly encrypted using the in-built encryption functionality. In cases where the participant went off-the-record this data was permanently deleted in the transcription process.

The data controller is The University of Sheffield and the data was stored in the University of Sheffield's Google Drive. This afforded high security whilst also providing access to individuals with the required authorisation. All of the data was password protected to increase the level of security of the data. This was achieved by encrypting the research data directly in the case of Microsoft Documents/ Spreadsheets as they have functionality which enables this. In the case of PDF's and audio files, the folders were compressed so that they could be encrypted. A personal laptop was used to access the data. This was enabled by the University of Sheffield Google Drive data storage which allows remote access to the data. The laptop is personal and not shared, it is also protected with a strong password. A University approved CAQDAS was used to analyse the data - NVivo.

A third-party transcription service was used to transcribe the audio files. This third party was on the University of Sheffield's list of approved transcription services as they meet the University standards and have a history of working with them. The sharing of the files occurred via this third party's own portal. The data included information which could aid in the identification of the participants and was consequently subject to GDPR. As such, the data was transcribed by EU/ EEA approved transcribers.

Consistent with GDPR, data will be stored until there is no longer a business need. In this research, that is three years after the research had been disseminated into the academic community as until that period it is possible that the data is still needed. In the meantime, the raw interview transcript data is archived in the University of Sheffield Data Repository.

4.6. Research methodology summary

This interview study aimed to (1) understand the inhibiting mechanisms which could impede the deployment of a blockchain solution throughout a supply chain; and (2) develop a framework which could explain some best practices for how to mitigate some of these inhibitors in order to have a successful blockchain deployment throughout a supply chain. As a result, this research sought to establish a theoretical contribution by adjusting the blockchain specific TOE framework, which was developed by Saberi et al. (2019), by incorporating additional theories such as integrity-based trust and calculative trust. To achieve this, a Critical Realist philosophical lens was used to construct meaning between individuals who had first-hand experience of events where blockchain systems had been either successfully or unsuccessfully deployed throughout supply chains. Semi-structured interviews were identified as the most appropriate evidence collection method as a consequence of the critical realist philosophical assumptions and the need for a research method which permitted the remote collection of emergent evidence. Participants were recruited through various channels; however, the majority of interviewees were contacted via social media. In total, 18 interviewees took part in this research with all of them having over three years of experience working with blockchain technology in varying capacities. The interviews were long-form discussions on the challenges which organisations face when they attempt to deploy blockchain solutions throughout their supply chains. Following evidence collection, Template Analysis was the preferred data analysis method due to the flexibility of the method in terms of philosophical disposition and evidence collection. Specifically, the works of Nigel King and his various collaborators heavily influenced the specific form of template analysis which was used to analyse the data. *A priori* codes were used as a means of grounding the research in the context of the extant literature which included the TOE framework in a blockchain context. A final template was produced which modified the Saberi et al (2019) adjusted TOE framework in order to explain each of the inhibitors to blockchain deployment throughout supply chains that was put forth by the interviewees (Research Question 2). This template in conjunction with the coded data was then used in order to deduce some of the best practices which can be implemented by organisations by targeting the causal mechanisms of the most prevalent barriers to

blockchain deployment throughout a supply chain (Research Question 3). In doing this, this research contributes a framework which can be used (1) as an industry aid to increase the likelihood of a successful deployment of a blockchain throughout a supply chain; or (2) an academic aid as a basis for future research into best practices with blockchain. Figure 7 provides a diagrammatic overview of the research process.

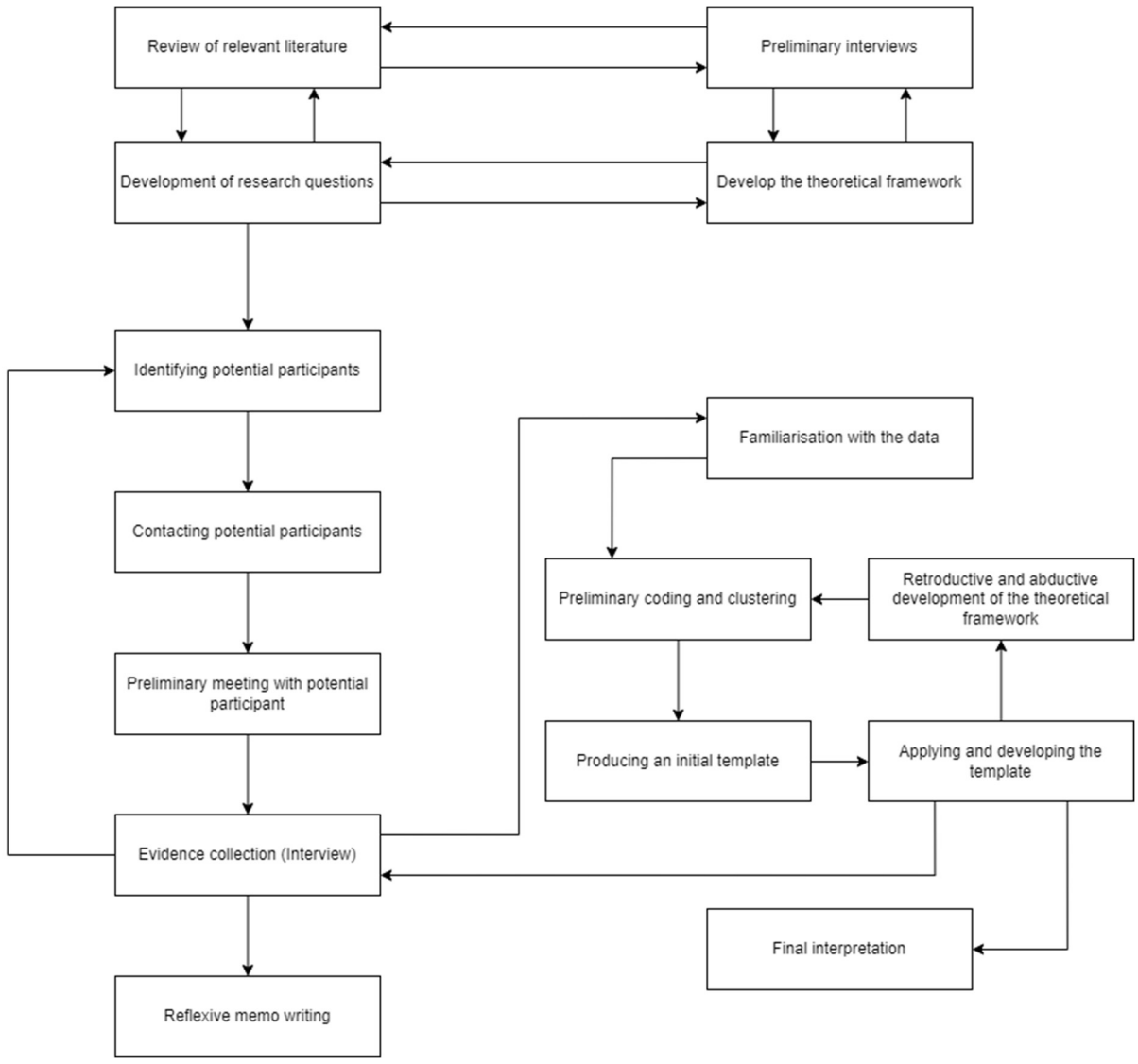

Figure 7: Diagrammatic overview of the research process

5. Findings and Discussion

This section reports the findings from the data analysis. King & Brooks (2017) state three approaches for presenting findings when using template analysis as the preferred data analysis method. This research applies the synthesis approach to link the findings back to the research questions. Firstly, the final template showing the main themes from the total dataset is evidenced. Secondly, a thematical presentation and discussion of the key themes from the interview data is provided. This section is structured around the research questions. The first subsection details the inhibitors to blockchain deployment throughout a supply chain (Research Question 1) with the majority of the discussion concerning the causal mechanisms that activate these inhibitors (Research Question 2). The second subsection explores actionable best practices that can mitigate some of the inhibitors which emerged in the previous section (Research Question 3). Within each of these subsections, the TOE theoretical framework is used to segment the findings and discussion according to theme. Thirdly, the cases are detailed and reported on individually. Then, these cases are used to explore the findings from the interview study by providing corroboratory or contradicting evidence in a case context. Lastly, cross-case comparisons are made between the cases and the interview data. Throughout each section, the findings are discussed in the context of the extant literature by evaluating how each finding supports or contradicts previously established results. Rationales are provided to explain any divergences between the findings of this research and the extant literature, drawing upon methodological, cultural, and technological variables which may have influenced the findings.

Consistent with the axiological assumptions discussed in Section 4.1.3., throughout each of the sections, steps are taken to improve the quality of the report. This is achieved in three ways which together aim to improve the transparency of the findings whilst acknowledging researcher biases. Firstly, direct quotations from the interview transcriptions are included to elucidate the points being made in the context of the raw data (King & Brooks, 2017; King et al., 2018; Lee & Saunders, 2017; Yin, 2018). This includes short in-text quotations which are used to inform the reader on the interpretations being made of the data as well as longer monologues to provide an insight into the raw evidence (King & Brooks, 2017). Secondly, extracts from the reflective memo writings are included to provide an insight into the

immediate reflections and assumptions made following each interview (King & Brooks, 2017). Lastly, vignettes are included which recount a short instance of an event happening within a case to better illustrate the context and conditions present within the case (Stake, 1995).

5.1. Findings from the Template Analysis of the interview data

As detailed in the methodology chapter, this interview study applied retroductive and abductive inferencing to understand the conditions which hinder the capability of an organisational entity to deploy a blockchain throughout their supply chain. This was achieved through a template analysis of the interview transcripts whereby codes were assigned to the interview data; applying the Saberi et al., (2019) Technology-Organisation-Environment framework for blockchain deployment throughout supply chains as an a priori starting point for the coding process. Following numerous iterations of the coding and clustering process, outlined in Section 4.4.2.2., A template of codes was developed which explained the issues which can occur when seeking to deploy a blockchain solution throughout a supply chain. The template identifies four first level codes – (1) Environmental barriers, (2) Organisational barriers, (3) Governance barriers, and (4) Systems barriers. Each of these categories contains second and third level codes with some containing further coding levels where appropriate. Table 11 below depicts the final template, while a full version of the template featuring all the definitions of each code is included within Appendix H. Despite Template Analysis permitting inconsistencies between the number of levels of codes, the final template within Table 11 only shows three tiers of codes to increase the readability of the in-text table. Shading is also utilised to further increase the readability whilst also including headings on each page of the table. Codes which feature an asterisk (*) next to them, denote a code which has child codes, but which was also coded directly onto the data. Within Table 11, where child codes are present, the codes have been aggregated from the child codes. The ‘files’ column details how many interview transcripts the code appeared in out of 18 total transcripts; whilst the ‘ref’ column accounts the frequency with which the code was featured throughout the entirety of the interview data.

Table 11: Final Template of challenges faced when deploying a blockchain throughout a supply chain, derived from analysis of the interview data

Category/ Code	Files	Ref
1. - Environmental Barriers	**16**	**92**
1.1 - Industry Challenges	10	36
1.1.1 - 3rd party Intermediary problems	1	2
1.1.2 - Different industries have different levels of understanding of blockchain technology	3	7
1.1.3 - Ease of blockchain deployment is industry dependent	5	19
1.1.4 - Lack of external examples	5	8
1.2 - Marketing Challenges	9	17
1.2.1 - Blockchain suffers from its own hype	6	9
1.2.2 - Crypto influences understanding of blockchain	5	5
1.2.3 - Crypto news can impact perceptions of enterprise blockchain	2	3
1.3 - Miscellaneous Environmental Challenges	2	4
1.3.1 - External factors can inhibit an organisations ability to invest financial resources to blockchain	1	1
1.3.2 - Some countries/ companies don't want blockchain to reveal their corruption	1	3
1.4 - Regulatory and Legislative Challenges	11	37
1.4.1 - Governing body agendas and-or standards challenges	5	10
1.4.2 - Different regulation in different countries	5	14
1.4.3 - Different regulation in different sectors	3	4

Category/ Code	Files	Ref
1.4.4 - Lack of regulation incentivising blockchain	1	1
1.4.5 - Regulation disincentivising or prohibiting blockchain features or functions	3	6
2. - Governance Challenges*	**18**	**384**
2.1 - Maintenance Challenges	6	19
2.1.1 - Competing stakeholder interests and objectives	3	13
2.1.2 - Establishing blockchain maintenance in governance	2	2
2.1.3 - Governance structures are difficult to maintain when issues arise	2	4
2.2 - Onboarding Challenges	18	357
2.2.1 - Off-chain governance challenges*	18	283
2.2.2 - On-chain governance challenges*	15	74
3. - Organisational Barriers	**18**	**318**
3.1 - Consultant Challenges	10	35
3.1.1 - 3rd parties can have blockchain platform preferences and biases	4	8
3.1.2 - Advertisement Dishonesty	5	14
3.1.3 - Blockchain providers lacking regulatory or industry understanding	3	8
3.1.4 - Poor communication between 3rd party developers	1	4
3.2 - Mindset Challenges	10	39
3.2.1 - Attitudes	8	26
3.2.2 - Motivations	7	13

Category/ Code	Files	Ref
3.3 - Organisation Size Related Challenges	10	18
3.3.1 - Larger Organisation Challenges	7	12
3.3.2 - Smaller Organisation Challenges	6	6
3.4 - Product Challenges	3	5
3.5 - Resource Challenges	11	36
3.5.1 - Financial Challenges	9	32
3.5.2 - Non-financial Resource Challenges	4	4
3.6 - Return on Investment Challenges	18	102
3.6.1 - Blockchain not aligned with business goals	3	5
3.6.2 - Difficult to establish the expected ROI	9	22
3.6.3 - Lack of desired ROI within budget period	8	13
3.6.4 - Necessity for blockchain ROI to add value	16	62
3.7 Workforce Challenges	15	83
3.7.1 - Disputes	4	12
3.7.2 - Lack of understanding	15	41
3.7.3 - Upper Management Challenges	11	30
4. - Systems Barriers	**16**	**94**
4.1 - Data Collection Challenges*	17	115
4.1.1 - Circumstantial Data Collection Challenges	14	40
4.1.2 - Data Accuracy Challenges	14	73
4.2. Functionality Challenges	17	126
4.2.1 - Blockchain accessibility and interactability	9	23
4.2.2 - Blockchain still in a state of relative infancy	8	22
4.2.3 - Data security issues	5	14
4.2.4 - Integration Challenges	14	37
4.2.5 - Lack of standardised maintenance of technology	1	3
4.2.6 - Payment rail challenges	1	2
4.2.7 - Smart contract challenges	5	6

Category/ Code	Files	Ref
4.2.8 - Supporting Technology Challenges	5	8
4.2.9 - Tokenisation of digital assets	3	5
4.2.10 - Transaction throughput speed	3	5
4.3 - System Decision Challenges	13	58
4.3.1 - Blockchain Platforms	12	35
4.3.2 - Blockchain Type	10	23

Each of the first level codes in Table 11 form the structure, according to theme, for the remainder of this section. The sections are ordered to correspond with their prevalence in the interview data. Each subsection describes their corresponding child codes and themes present, and uses a series of short in-text quotations; long-form monologues; extracts from memo writings; and vignettes to transparently portray the interview data (King & Brooks, 2017; King et al., 2018; Lee & Saunders, 2017; Stake, 1995; Yin, 2018a). Each subsection also features tabulations of the corresponding codes which were extracted from the full template. Unlike Table 11, these tabulations detail all of the codes within the category alongside their identifier, and details about the number of times the codes was cited in the interview data. Each tabulation is sorted according to the total number of references of a code which were applied to the interview transcripts.

5.1.1. Governance Barriers

Governance Barriers accounts for issues which occur when the Deployment Lead organisation attempts to onboard its Supply Chain Members to the network and establish new means of collaborating with the Supply Chain Members when using the blockchain solution. Thus, the tier two codes of Onboarding Barriers and Maintenance Barriers were used to differentiate between the two phases of the deployment from an

interorganisational perspective of the relationship between the Deployment Lead and the Supply Chain Members. As a result of the findings within this study, Governance Barriers was the preferred term for the category over the closely related *a priori* code of Interorganisational Barriers as it accounts for some of the limitations of the interorganisational barriers category by expanding the scope of the definition whilst also adding an inherent objective to the definition. In accordance with Pelt et al. (2021, p21) Governance in this paper is defined as "the means of achieving the direction, control, and coordination of stake-holders within the context of a given blockchain project to which they jointly contribute". Thus, the term Governance more accurately captures the objective of the project and the dimensions where issues may arise than Interorganisational Barriers does, whilst still acknowledging the interorganisational context. As is detailed and evidenced throughout the remainder of this chapter, blockchain collaborative and interorganisational issues are frequently organically raised by the interviewees in relation to value different stakeholders will receive from the implementation. Further, the term 'Governance' is commonplace within the blockchain industry and academic space (Beck et al., 2018; Karajovic et al., 2019; Lu et al., 2021; Pereira et al., 2019; Wong et al., 2020; Xu et al., 2019; Yermack, 2017). The decision to replace collaboration and interorganisational challenges with governance was also a consequence of the verbiage the interviewees within this study demonstrated. For example, as is evidenced in the verbatim extracts throughout the remainder of this section, Interviewees 2, 8, 10, 12, 14, and 17 utilise the term 'Governance' in alignment with Pelt et al. (2021) on numerous occasions throughout their respective interviews.

Within the Onboarding Code, the challenges were divided further into On-chain Governance Challenges, and Off-chain Governance Challenges. These two tier three codes differentiate the challenges according to where they occur. On-Chain Governance Challenges refer to issues which occur between Deployment Lead and Supply Chain Members specifically on the blockchain network; whereas Off-chain Governance Challenges pertains to business issues which are not directly concerned with the blockchain. Within the study, Governance Barriers represented the most numerous challenges which were discussed during the interviews and this is reflected in frequency of codes which were assigned to the data. Table 12 details each code within Governance Barriers ordered according to frequency within the total dataset.

Table 12: Governance barrier codes alongside the number of files in which the code appeared and the number of times data was referenced with that code in total

Code ID	Governance Barrier Codes	Files	References
GOV01	Lack of incentive to join the network	17	82
GOV02	Lack of power or influence over supply chain	11	30
GOV03	Lack of collaborative business models	7	23
GOV18	Low existing supply chain digitalisation	9	21
GOV31	Off-chain governance challenges*	7	20
GOV04	Lack of rights and lack of clarity of rules of engagement	9	19
GOV21	Disagreements around on-chain permissions*	12	18

Code ID	Governance Barrier Codes	Files	References
GOV05	Lack of standardisation for onboarding	6	18
GOV09	Multi-geographic supply chain challenges	6	14
GOV27	Disagreements around infrastructure	5	14
GOV33	Competing stakeholder interests and objectives	3	13
GOV28	Deciding what data is stored on-chain	4	12
GOV06	Lack of clarity in funding sources	3	11
GOV29	Difficult to establish initial governance structures	3	10
GOV30	Governance Barriers*	5	9
GOV10	Cultural supply chain challenges	3	9
GOV13	Quantity of onboarded organisations	5	6
GOV12	Failure to onboard key partners	3	6
GOV32	On-chain governance challenges*	3	6
GOV15	Poor relationships with supply chain members	3	5
GOV14	Difficulties onboarding risk averse or highly regulated members	2	5
GOV34	Governance structures are difficult to maintain when issues arise	2	4

Code ID	Governance Barrier Codes	Files	References
GOV16	Onboarding competitors challenges	3	3
GOV23	Lack of desire to share data	3	3
GOV19	Low supply chain understanding of blockchain technology	2	3
GOV22	Refusal to share product secrets	2	3
GOV24	Lack of trust in the data	2	3
GOV25	Lack of supplier trust in how the data will be used	2	3
GOV17	Conflicting roadmaps and schedules	2	2
GOV26	Data privacy challenges	2	2
GOV35	Establishing blockchain maintenance in governance	2	2
GOV20	Lack of internet access in supply chain	1	2
GOV07	Issues with unbanked businesses	1	1
GOV08	Onboarding too expensive for suppliers	1	1
GOV11	Lack of technical expertise in some geographies	1	1

5.1.1.1. Governance barriers – Governance Onboarding

The vast majority of respondents discussed the need to establish an approach for onboarding supply chain members where the members received some form of benefit for joining the network. This stemmed from a consensus between participants that there is a need to provide value to any member which is being onboarded to the network.

"The biggest issue with supply chain actors if you ask them to join the blockchain, it's always, what's in it for me?... In practical examples you have suppliers who go, okay, so if I provide you with those seven attributes and you put them into the blockchain, are you going to pay me quicker? Are you going to pay me more? What's in it for me? I know what's in it for you, but what's in it for me? That's the conversation that holds up discussions." – Interview Participant 10

This finding is discordant with the early conceptual work of Angelis & Da Silva (2019). Their paper aimed to provide managers a framework which could be used to action and question aspects of their blockchain project. The authors suggested that it is necessary to establish what value the project is intended to create. They continue by detailing examples of value that may be added through a blockchain project; however, all of the discussed value, none of them take a supplier centric approach that aims to establish value outside of the initial onboarding. Similarly, some interviewees extended upon this by stating that there is a need to identify an approach within the governance of the network which creates value for the entire supply chain, rather than just being focused on one member at a time.

"If there is no governance model that people could come up with, that benefits everybody in the network, it will completely derail the blockchain implementation at the pilot level… That incentivises everybody in the network… Otherwise, whoever it doesn't incentivise, they would be the first ones to move themselves out." – Interview Participant 08

This is concordant with the conceptual work of Beck et al. (2018) who reasoned that incentive alignment for the onboarded users is necessary to consider in order for the users to engage with the network. Moreover, some participants explained that the characteristics of each supply chain member require the value to be tailored to the specific member whom is being onboarded to the network.

"Farmers are very practical people. What's in it for me? They're practical people." – Interview Participant 04

Whilst one participant extended upon this by detailing the system they use at their Technology Provider Organisation which aims to account for the different profiles and benefits of the supply chain members. This approach combines the benefits of the tailored approach whilst still having an overarching strategy for onboarding supply chain members by differentiating between different profiles of supply chain member according to what value they would like to get out of joining the network.

"That's why we divide the different partners into different tiers. Tiers in terms of what are their common challenges and what would benefit them to be part of such an organisation. It can be automation of processes they have had to do manually in the past and through being part of this platform can just be automated, for example." – Interview Participant 17

Whilst others acknowledged that the creation of incentive mechanisms which create common value for several companies is in itself the main challenge in onboarding. This finding extends upon the conceptual research of Beck et al. (2018) by acknowledging the need to create a communal value between the involved organisations, but by recognising that this value must be tailored to each participant in order to ensure the participants realise sufficient value from their involvement in the project.

"But regardless, it's a human anthropological business problem of how do you align the incentives of multiple companies together in a way that can be codified in business contracts?" – Interview Participant 02

Several interviewees discussed the duality of the supply chain onboarding process as being related to incentives and power. These interviewees explicated that there are two approaches for onboarding the supply chain. One involves creating value for them to join the network, whilst the other involves leveraging influence to have the supply chain members act in the deployment leads interests.

So, they can either beat them with a stick to do it or find a carrot to bring them in to say, look, this process is going to be best for everybody. – Interview Participant 02

"And using a hammer is not always the most convincing way, so you need to find ways to show everyone how they are benefitting from the system." – Interview Participant 09

"Hey, we need you to do this, in some case you twist their arms, sometimes you articulate the value for each. Hey, farm, if you're growing these amazing tomatoes, if we put your name in the chain, and maybe there's interest and publicity for you." – Interview Participant 12

One participant explained how onboarding through power is very similar to onboarding through incentives as when there is a power asymmetry in place, the incentive is that you retain your position as a supplier to the Deployment Lead organisation(s).

"The value there is you're still my supplier. Through this market dominance you can do that." – Interview Participant 17

Alternatively, some participants explained that both incentivisation and power are viable means of onboarding supply chain members, but that onboarding through power as a method is limited as it can create issues in maintaining the governance structure later on.

So, if the company has got very strong financials, much bigger than most of the suppliers that it is working with, it obviously has got more power and more wherewithal to get more people onboarded on the network, with, of course, the right governance model. So, see, the thing is they can come for fear, but they are not going to stay for that. If you are a very big company, you can make them feel that fear, that if you don't join this network, I'm going to stop doing business with you. They'll probably come for that. – Interview Participant 08

"If there is a power asymmetry in place, then the big guy can pay for it and try to force all their suppliers on. Large Multinational Retail Organisation has tried that and it failed. It's not a good strategy". – Interview Participant 10

"The intent is it's supposed to be a small set of companies as a leading body. The reality is there's almost always what I would call an anchor member in the consortium. It's almost exclusively a single party doing that. And then trying to convince the others, that don't worry, at some point we're going to balance this governance out, that we'll be leading it. And that's where we tend to see, I tend to see, these consortiums fall apart." – Interview Participant 02, Follow-up

Perhaps most interestingly, some participants insinuated a preference for onboarding through incentives, whilst acknowledging that onboarding through power is more common within industry at the moment. This is supported in how within the interview data, more participants spoke about onboarding through incentives; but when giving specific examples they often referenced very large multinationals which have been able to influence their supply chains to join their blockchain networks.

"The other side of the coin is where you have the 800llb gorilla that's the biggest buyer in the category. And says, when I buy from you, unless you give me these data attributes, and these documents, and these insights, I'm no longer going to buy from you. And we do see that a lot, unfortunately." – Interview Participant 05

This finding may be discordant with Saurabh & Dey (2021). In their study which also incorporated the TOE theoretical framework, they were seeking to understand which factors incentivised blockchain adoption in wine supply chains. They included coordination control as a factor, which was derived from early works in transaction cost economics by Williamson (1975, 1979, 1993). This factor accounted for the influence an organisation had over another organisation according to the interdependence of the two firms. In their study they found that coordination control was the least influential factor in determining blockchain adoption. This contrasts the sentiments of many interviewees within this study as on several occasions' interviewees expressed their preference for creating shared value as a means of onboarding individuals to the network. However, it is possible that these findings are not discordant as it could be evidence that these two findings refer to different time periods in the onboarding process. This is because this study focused on scenarios which occur once the decision to deploy a blockchain solution has been made; whereas the Saurabh & Dey (2021) are looking at motivations to adopt a blockchain solution. Thus, whilst power asymmetries may not incentivise blockchain adoption, they may make it easier once the blockchain deployment is actioned. However, the interviewees in this study still implied, and in some instance explicitly stated, that blockchain projects in instances where power asymmetries are present are more common; whilst no evidence was found which suggests that onboarding through incentives was more prevalent than onboarding through power.

5.1.1.2. Governance barriers – Governance model negotiation

Throughout the interviews, several interviewees explained how establishing the governance structure is the main challenges facing the deployment of blockchain solutions throughout supply chains; with some participants noting that governance structures do not receive enough attention currently. This finding begins to elucidate the call for further research into blockchain governance in supply chains put forth by Saberi et al. (2019). In their study, establishing governance structures in terms of their effectiveness was one of their key propositions. Their rationale was that traditional supply chain governance structures which they reasoned were derivatives of transaction cost theory, need to be tested in instances where a blockchain is present. They continue by questioning if all extant governance structures will exist equally on a blockchain medium, or if blockchain technology more readily lends itself to a particular governance structure.

"Apart from that, at the end of the day, it all boils down to the governance model, and unfortunately, not enough people are talking as vocally as possible on the governance model structure." – Interview Participant 08

"But most of the projects that have failed post POC and pilot are because they could not get a lot of… They could not establish a good governance model… And one of the key reasons for people failing from POC to pilot movement is because of governance models." – Interview Participant 08

The interviewees explained several key discussion points which can impact the governance model structure when the Deployment Lead is seeking to onboard supply chain members to the network. Firstly, several participants explained there are three broad governance structures which can be established – (1) Anchor, (2) Consortium, and (3) Community. An Anchored Governance structure revolves around the Deployment Lead organisation and each Supply Chain member has to follow the rules for engagement presented by the anchor organisation. The Consortium Governance involves the Deployment Lead collaborating with a few key stakeholder members in order to collectively establish the rules of engagement for the blockchain. Lastly, the Community Governance structure involves every member

mutually establishing the rules for engagement where no single organisation leads or controls the blockchain project.

"There are three ways you do it. One is to use centralised authority, let's say you are the big distribution unit, you want everybody on blockchain. So, you say, this is my terms. Come, and this is my governance. Fine. Second one is you say, okay, here's a playground, everybody come to play in this playground, we can all decide what the rules are. So, that's a second way. I think industry is still not able to give away the first, and they're trying to move to the second. But, it's almost like if you're still a central authority, but you decide, okay, I'm going to have these ten players in the playground, right? … Now, the third one is where you say, literally create, it's almost like a DAO, decentralised autonomous organisation. And you establish it's for the community, by the community, everybody owns but nobody owns, right? So, there is a governance that is mutually established." – Interview Participant 12

However, due to their very limited existence, none of the interviewees had experience working with Community Governance blockchain projects in supply chains. One participant notes that the difference between these governance models comes down to control, and the different degrees of control each cooperating member has within the system.

"There's always going to be a level of control. There has to be a level of control. How you ethically distribute that control of the network I think is where the challenge comes in and actually orchestrated as such." – Interview Participant 02

When establishing the governance model, several participants note how challenges can occur pertaining to three key criteria which affect the governance model – (1) rules and permissions, (2) funding, and (3) governance structure and infrastructure. Most prominently, several interviewees discussed how the governance model dictates the rules and permissions each organisation has within the network.

"And this comes back to, what is the system design, what is encrypted and who has access to what data?" – Interview Participant 09

"Issue number two comes into privacy and the ability of these organisations to put private information on any kind of blockchain, public or private, that's the second largest issue." – Interview Participant 16

This appears to be a significant challenge that faces Deployment Leads in how they establish the permissions of each supply chain member on the network. One interviewee who worked for a technology provider organisation noted that most common question which they are asked pertains to who can have access to the supplier's data. The interviewee noted that suppliers may not wish for their data to be visible to certain members of the network. Suppliers need to be aware of who their data is being shared with, and this needs to be negotiated to ensure that data is only visible to those who have permission. Thus, there is a need for the deployment leads to be aware of this issue and to be accommodating of the suppliers which they are seeking to onboard to the network. This finding is concordant with Wang et al. (2019) who found that issues in establishing data ownership and intellectual property were very prominent in their interview study. Privacy concerns were also one of the most significant challenges in Van Hoek's (2019) survey research. However, in the case study segment of their research, none of the three case organisations perceived privacy concerns as a barrier. The author reasons that this may be a consequence of the three studied cases being pilots, whereas privacy concerns may become more prominent as the solution scales to many users. Thus, this research supports the quantitative results within the Van Hoek (2019) study. This is significant as this provides qualitative evidence of data privacy as a significant barrier to blockchain deployment which was not found within Van Hoek's (2019) case study research. Risks associated with data privacy was a receiver barrier Biswas & Gupta's (2019) study as they concluded that causal barriers such as technological scalability barriers needed to be prioritised in order to solve the privacy challenges. Given the lack of prominence of the causal barriers in their study within this study, it may be considered that as the causal barriers have been addressed over

time, that issues related to privacy have been mitigated which can be evidenced in this study.

*"*The questions that we have is more around permissions, entitlements and how do I slice and dice the data*… So, yes, because every actor wants to contribute data to that digital object and retrieve data from that digital object. And based upon permissions and entitlements, not all data is going to be shared freely with all parties. And so, you have to have this permissioning and entitlement matrix to say the farmer is willing to share data with party one, three and seven, but not two, eight, nine and ten." – Interview participant 05*

Interestingly, trust was discussed as a causal mechanism which can either mitigate or exacerbate the issues surrounding rights and rules of engagement. However, the form of trust being discussed varied in nature quite drastically between interviews. Firstly, one interview participant noted how in instances where trust is non-existent, then this cannot be overcome as the supply chain members will not be willing to share data with the deployment lead organisation. Notably, the interviewee implied that they were referring to integrity-based trust between the deployment lead and the supply chain member being onboarded by providing example questions which pertain to the intent of the deployment lead, as opposed to the competence of the deployment lead. Thus, where the causal mechanism of low integrity-based trust is present, establishing the rules and rights of engagement on the network is likely to be a significant barrier to the deployment of the blockchain solution.

"If the trust isn't there or the willingness to work together, we cannot, and other people like us simply can't do our job. And so, if you ask someone for information, they are going to want to know, well, what are you going to do with it? Why do you need it? And a thousand questions." – Interview Participant 05

This finding extends upon the early blockchain work of Francisco & Swanson (2018) who proposed that inter-organisational trust would mediate the relationship between various

factors and the decision to deploy a blockchain solution by accounting for integrity-based trust and competence-based trust. Similarly, this is also extends upon the literature review study by Clohessy et al. (2020) by finding integrity-based trust as a causal mechanism which can exacerbate or mitigate rules of engagement challenges. In their research, the authors found that trust and data privacy concerns were issues which must be addressed prior to the implementation of a blockchain system. Further, whilst the research methodology only permitted insight into frequency as opposed to significance, trust was found to be one of the most frequently discussed issues surrounding blockchain deployments in the studied literature.

Likewise, Interview Participants 06 and 16 also commented on how a lack of interorganisational trust could be a condition under which the deployment of a blockchain solution could be hindered. Participant 16 acknowledged a difference between public blockchain solutions and private blockchain solutions as he specified that every operator of a node when using a private blockchain solution must be trusted. Whilst not specifically explained, Hastig & Sodhi (2020) stated that interorganisational trust was one of the critical success factors which needed to be present in order for collaboration to be successful when deploying a traceability blockchain solution. However, it is not stated if they are referring to trust in integrity, competence, or a combination of both trust forms.

This finding can be observed in the literature review study and survey data collected by Yadav et al. (2020). The authors were able to determine the level of influence each factor had over the other factors. This enabled them to differentiate between the different types of challenges which need addressing by accounting for the order in which they should be addressed. Notably, the authors found that 'lack of trust among agricultural stakeholders' was one of the most significant causal mechanisms with regards to how it influenced other challenges. This factor had a large influence on several other barriers, with 'Agricultural stakeholder resistance to blockchain culture' as the most influenced barrier of lack of trust. Thus, in instances where there is a lack of trust, there is an increased likelihood of resistance to the blockchain project by the supply chain members and relevant stakeholders. However, unlike Interview Participant 06, Participant 10 found that a lack of competence-based trust to be a barrier to the deployment. The interviewee noted how they consistently find that they have to justify to the suppliers that their data is safe. Thus, this implies that the

suppliers trust the intentions of the deployment lead, but they are not trusting of their competence to securely store the data and to share it with the agreed upon partners. These two findings in conjunction suggest that both integrity-based trust and competence- based trust are causal mechanisms which can greatly impact the deployment leads capacity to onboard supply chain members to the network.

"They said their biggest issue was trying to convince their suppliers that their data was safe. That's a consistent message that we have." – Interview Participant 10

Conversely, when probed on trust, Interview Participant 12 stated that "trust in data" was a significant issue of the supply chain members which he had worked with. This is notable as this is unlike the previous two modes of trust which were discussed as they were both interorganisational in nature; whereas trust in data refers to the trust between an organisation and a technological system. However, the interviewee did note that trust in data also has its underlying causes in both integrity-based trust and competence-based trust. Showing that these causal mechanisms are not binary and that both, one of, or none may be present. This finding extends upon the hypotheses developed by Francisco & Swanson (2018) who suggested that trust in the technology would act as a mediating variable for various other factors on the behavioural intention to deploy a blockchain solution by including technology-based trust but it been evidenced as a mediating variable for the negotiation of rules of engagement at the onboarding phase in this study. Trust in technology in relation to blockchain was researched in Wong et al. (2020b). They posited that trust in blockchain technology would positively impact the behavioural intention to adopt blockchain. However, this was not supported. This finding is not necessarily conflicting with this study, as the Wong et al. (2020b) study was looking at variables which can predict adoption; whereas this study was focused on underlying barriers which may derail deployment and as such, the dissimilarity between the findings may be explained by the different objectives of the research methodologies.

"Trust in data. If you're giving me the data, how do I know it's true? And let's say it goes along multiple steps in the process. Let's say, in the food world there was this whole thing about, if there was a food scare, E.coli poisoning, how do you now track back as to which farm this disease came from? So now, you have a data, but what if somebody tampers with the data?" – Interview Participant 12

Another causal mechanism which was discussed as exacerbating the negotiation of the governance model was an environmental challenge. Interviewee 02 noted how each organisation which is being onboarded to the network has their own legal challenges to which they must comply. Meanwhile, the deployment of a blockchain requires that each company's legal challenges are accounted for by one system. Thus, the blockchain itself has to be capable of accounting for each supply chain members own internal legal challenges. This greatly increases the complexity of the negotiation simply due to the quantity of organisations which are attempting to collaborate.

"And so, each company has their own legal challenges internally in and of itself, and you try to get them all to come together to agree and it just exacerbates that tenfold or a hundredfold depending on the party. So, typically that agreement around the governance of the network, given the limited capabilities of governance that really exists in enterprise networks today for real true on-chain governance, which is challenging to achieve, makes it difficult for these networks to scale." – Interview Participant 02

The second most discussed issue at the Governance Model Negotiation phase is in the funding. Namely, the upfront costs for how the blockchain project will be initially funded as well as the continued funding throughout and post deployment.

"So, what I see as problem is mainly governance or that have properties which is linked to governance somewhere. And who is paying what" – Interview Participant 14

This is an issue as which varies according to governance model. In situations where a single deployment Lead is anchoring the blockchain project, then funding becomes simpler as generally they will fund the majority or all of the project. However, when using a consortium governance structure where select key partners collaborate for the deployment the blockchain has to be negotiated between the partners. This can increase complexity as different organisations have their own respective level of interest in the project and value which they can attain from the project.

"The other big problem when you're going through this process is who pays for it. That's a big issue. A lot of the blockchain companies will try to get funding to support it from the company that they're dealing with to have skin in the game." – Interview Participant 10

Lastly, challenges can occur when negotiating the blockchain infrastructure with each of the supply chain members. The most frequently discussed issue raised by the participants refers to the indecision between whether the supply chain members host their own infrastructure, or if the deployment lead will host all of the infrastructure.

"What you cannot solve like technical aspect is distribution of the node, who is holding them, who is running the node, how can you manage the onboarding. Onboarding is not easy task at all." – Interview Participant 14

Each of these three challenges which need to be negotiated – Rules and permissions, funding sources, and infrastructure – are each subject to several underlying contextual governance conditions which can exacerbate or alleviate each challenge. Several interviewees noted how the geography which the supply chain network operates in can impact these issues. One interviewee stated how from a practical stand point, having a supply chain operating in several countries or continents greatly increases the difficulty in viewing the supply chain which can inhibit understanding.

But again, that's time-consuming and expensive. Not all clients are willing to allow you to come on-site, to be frank, sometimes. So, yes. A supply chain of growing almonds in California, turning it into almond milk in Illinois and seeing it on a grocery store in New York City, is a lot easier than sourcing avocadoes from Peru and seeing them go to Shanghai, yes. – Interview Participant 05

Another way geography can impact the deployment is specific to the countries which the supply chain operates in. For example, Interview Participant 09 notes how deploying a blockchain in China can present hurdles as the Chinese government require for information to be stored on their own blockchain; which can increase the chances of competitors being able to view the data.

Well, in some countries… Like China. When the Chinese government requires that all data be stored on local servers and that they have access to everything, if you have foreign companies that are concerned about their Chinese competitors having access to their data. – Interview Participant 09

Interview Participant 06, explained that geographical challenges can also manifest in the form of cultural issues. This finding is concordant with the findings of (Wang et al., 2019). In their interview study, the authors found that cultural challenges were one of the most frequently raised issues made by the interviewees. This was an issue which Saberi et al. (2019) also predicted as they stated the cultural challenges would be expected to be a causal mechanism for exacerbating collaboration challenges. This finding was also found against a different theoretical backdrop. In their survey research, Kouhizadeh et al. (2021) found that cultural differences between supply chain partners, inhibits challenges concerning information disclosure between organisations, and it also can exacerbate challenges in integrating business operations with the new blockchain solution. However, it is necessary to caveat that these findings are based on perceptions of blockchain deployments, in a sample where it was not necessary to have first-hand experience working to deploy a blockchain solution. This is necessary to mention because this finding was

observed from the academia sample within their research, and, whilst present, it was less prominent in the practitioner sample. Interviewee 06 extends upon the aforementioned research by increasing the specificity of cultural challenges. They stated that there is a need for the collaborating organisations to "*have a shared value system",* implying that when value systems between organisations do not align, then this can increase the opportunity for behaviours which are not in the interest of the partnered organisation. Similar findings were made in the of Clohessy & Acton (2019), the authors found that trading partner support was a barrier to blockchain deployments in supply chain in only three of the included studies (Clohessy & Acton, 2019). These findings in conjunction acknowledge that cultural challenges may not be the most frequent challenge, but that when they occur they may be significant. This finding also expands upon the survey research of Kouhizadeh et al. (2021). Their research showed that both academics and practitioners viewed collaboration challenges as being one of the most prominent issues facing blockchain deployments throughout supply chains. This finding extends upon that of Kouhizadeh et al. (2021) in two ways. (1) It demonstrates the prominence of collaboration issues in deploying blockchain solutions throughout a supply chain by employing a data collection method which captures context. (2) It provides insight into a potential causal mechanism that can lead to collaboration challenges by acknowledging the role of shared value systems in supply chain partnerships.

Several interviewees discussed how specific characteristics of the supply chain member could also influence the ease of deployment of the blockchain solution. Firstly, Interview Participant 08 points out how because of blockchains infancy, it is still a technology which is for early adopters who have a positive attitude towards some level of risk; whereas laggards who are more risk averse would be harder to onboard to the system. This problem is especially prominent in blockchain deployments as just because the Deployment Lead organisation or consortium have an early adopter mindset, this does not necessarily extend to the supply chain members.

"So, there is an S-curve for adoption for any new technology. So, there are some early adopters and there are some laggards, and then there are some fence-sitters. So, a lot of

resistance can come from where that industry sees itself or where that company sees itself in the S-curve." – Interview Participant 08

Secondly, numerous interviewees not how the status of the existing relationship prior to the potential introduction of the blockchain solution can be a causal mechanism which affects deployment. One participant noted how trust, as discussed previously as a causal mechanism, can be an observed outcome of the relationship between the supply chain members. Thus, suggesting that trust is an outcome of previous behaviours and interactions between the organisations. In this scenario, trust would be considered as being a finding within the actual, whilst historical actions between the involved organisations is the true underlying causal mechanism which can influence trust.

"Yes, the first thing, and it's probably the most important, is that do you work well with these other people within your supply chain? Do you have a good relationship, and do you trust them?" – Interview Participant 05

Likewise, another participant noted how when long-lasting relationships have been forged between the collaborating organisations, that this can again ease the deployment as there is a pre-existing familiarity in collaborating together.

"It depends on the supply chain. Some supply chains have very well-established relationships with each other. For example, in the coffee industry, you have long-lasting relationship for years. There it's easier to form those consortia and form those partnerships to do such a thing." – Interview Participant 17

Conversely, Interview Participant 05 gave an example where length of relationship could prove an inhibitor of successful deployment. The participant stated that in circumstances where the supply chain member had been treated unjustly, or promised outcomes which

were never delivered, then the length of the relationship could magnify the levels of distrust which can in-turn prohibit deployment of the blockchain.

"And they're trying to get the farmers a fair wage, and they've been saying this for 30 years. And in 30 years, nothing has changed. And so, they have a really strenuous relationship with the farmers, because they don't want to pay more for the ingredient, because then their margins collapse, right? So, that is an environmental issue that technology cannot solve." – Interview Participant 05

A second characteristic which can have an adverse impact on deployment, is when the deployment reaches a specific critical partner. A critical partner is a supply chain member or stakeholder who's onboarding to the network is paramount due to their importance to the function of the network. In these instances, if a key partner refuses to join the network, then this can have an indirect impact on other potential organisations which are being onboarded to the network as the network will offer a limited amount of value without that key partner.

"Well, typically the ones that have agreed to join the consortium and the governance model are fairly active or are willing to accept the rules of the consortium. That governance, up to that particular point, usually there is either, once there's scaling to a critical partner to join the consortium that does not fundamentally agree, is where things will tend to break down." – Interview Participant 02

Likewise, whilst their case study research focused on organisational challenges facing blockchain deployments, Clohessy & Acton (2019) documented one case where a large organisation stated that they were having difficulties encouraging supply chain partners to buy into the platform. The authors acknowledge that this is despite the case focal firm having all the required resources to develop its own proprietary blockchain system. However, the study does not permit further insight into why they were facing this challenge as it is outside of that studies scope. Similarly, Interview Participant 14 notes how these

critical partners do not necessarily have to be supply chain members; but instead can be any stakeholder whom has an involvement which is critical to the function of the blockchain. In their example, they discuss how banks can be extremely difficult to onboard to the network; especially when several banks are needed to cooperate on the project. Interestingly, the interviewee specified how the size of these organisations can also further exacerbate onboarding challenges. This is presumably a result of power asymmetries running similar so there is no powerful anchor which can force through the deployment.

Because one of the main issues that we see in the industrial sectors is, which is not the cases for banking or insurance, where if you are four banks dealing together, it's a nightmare, but they are all of approximately the same size. – Interview Participant 14

Lastly, one participant noted how a similar issue can occur as a result of the sheer quantity of onboarded organisations. As each stakeholder is added to the network this increases the complexity of the negotiation pertaining to the rules and rights of participants, the infrastructure, and the funding sources. This finding is concordant with Wang et al. (2019) who found that when deploying a blockchain system throughout a supply chain, the number of stakeholders of the system that are affected by the system, drastically increases the challenge of deploying a solution which is compatible with the stakeholders needs. Notably, interviewee 17 cited the new ways of collaborative working which must be developed between the involved organisations as being the underlying causal mechanism which can inhibit the deployment of the solution.

So, for a blockchain solution you want to bring all of them on the table, which is not going to be a super-easy task. So that really inhibits collaboration. It's something people are not used to. It's completely new. So yes, there is a lot of challenge on communication between all of these participants or stakeholders. - Interview Participant 17

5.1.1.3. Governance barriers – Governance model deployment

As was mentioned in the final paragraph from the previous chapter, establishing new ways of working was cited as a causal mechanism which can impact the negotiation of rights, infrastructure, and funding sources for the blockchain project. However, establishing new ways of collaborating is also an issue which several participants reference as being a challenge which can also occur after the deployment of the blockchain solution with the Supply Chain Member. Specifically, a majority of the involved participants referred to the need to establish new collaborative business models that function in accordance with the new blockchain system. This finding is concordant with Wang et al. (2019) who found that changing operational protocols is a significant challenge to blockchain deployments throughout supply chains. Notably, in their study they found the cultural, collaboration, and governance category of codes, which changing operational protocols was a sub-code of, represented the most prominent challenges facing deployment. For example, Interview Participant 08 acknowledges that there is a conventional way of doing business which will be required to change to a holistic, supply chain centric approach, when a blockchain is added to link the entire network. Further, this is supporting of the propositions of Saberi et al. (2019) who state that blockchains create novel means of working and that there is a need to develop coordinated business operations with the supply chain. This finding was also evidenced within Clohessy & Acton's (2019) literature review. Whilst not explicated how this is defined, 'business model readiness' featured in roughly half of the literature studied.

"How do I make sure that my supplier doesn't fail? Because if my tier three supplier fails, my tier two supplier fails, and as well, my tier one supplier fails. And if my suppliers fail, my systems are going to fail. If my distributors fail, my systems are going to fail. Now what we are talking about is a more collaborative business model which is different from the way that we have been doing business for some time." – Interview Participant 08

This finding is also concordant with Wang et al. (2019) and Saberi et al. (2019). Wang et al. (2019) found that changing operational protocols is a significant challenge to blockchain deployments throughout supply chains. Notably, in their study they found the cultural, collaboration, and governance category of codes, which changing operational protocols was a sub-code of, represented the most prominent challenges facing deployment. Similarly, in their conceptual study, Saberi et al. (2019) proposed that blockchains create novel means of working and that there is a need to develop coordinated business operations with the supply chain. As a result, this finding provides empirical support for the proposition of Saberi et al. (2019).

Interview Participant 17 extends on this by also noting that as you expand and deployment, you often end up having to develop collaborative business models with competitors. Thus, working collaboratively with competitors can inhibit the ease of deployment. This finding is concordant with some of the findings form Kouhizadeh et al. (2021). In their study, academics perceived blockchain integration with the supply chain business process, specifically sustainability orientated practices, was a significant challenge. However, the industry practitioners did not place the same level of emphasis on this variable. This may be a consequence of the value systems regarding sustainability between industry and academia within their study. Further, the value of this study as a concordant finding is diminished as their study placed a greater emphasis on sustainability than in this research. Notably, interviewee 17 also included interest and objective alignment as an underlying causal mechanism which can exacerbate the challenges in developing collaborative business models around a blockchain solution.

"It's maybe less governance of the blockchain itself but working together with partners you usually don't work together or haven't worked together with, to form something new and working towards a common goal. This can be easier if you've already got partners, but the larger you go with blockchain sometimes you also encounter to reach out to your competitor, because it's like an industry solution" – Interview Participant 17

This is concordant with the findings of Hastig & Sodhi (2020) from their thematic analysis of the extant literature. Collaboration is one of 6 critical success factors which the authors find must be present in order for the successful deployment of a traceability blockchain throughout a supply chain. They extend upon this by acknowledging interest and objective alignment specifically with the supply chain partners as being one of the underlying causal mechanisms for determining if collaboration will be successful. Similarly, Interview Participant 11A described how each time there is a competing interest, this increases the complexity of the deployment as it becomes harder to accommodate every competing interest within the governance of the network. This finding extends upon that made by Wang et al. (2019) who also found that interest and objective alignment can be an inhibitor to blockchain deployment in supply chains.

"And there was no concept, really, of just how many vested interests or corporate interests or commercially sensitive aspects and the complexity of that." – Interview Participant 11A

Another issue which occurs during the deployment phase is in the level of digitalisation of the supply chain. Specifically, the level of digitalisation of the supply chain member which is being onboarded to the network. This is an issue which has been observed by Interview Participant 06 who stated that the level of digitalisation of the supply chain member directly affects the difficulty of her job as an advisor to blockchain deployment projects. In circumstances where the supplier has a low level of digitalisation her job is harder than when they have a high level of digitalisation. This finding shows some support for the early hypotheses of Francisco & Swanson (2018) who stated that an organisations existing technical infrastructure could either increase the likelihood of adoption if it is a sophisticated system, or it could deter adoption if there is a low level of existing digitalisation. However, one limitation of this is that the authors were unspecific in referencing which organisations need to have the technological sophistication. This finding is also concordant with an inverse finding from a later empirical study which was looking at drivers of blockchain technology as opposed to barriers of blockchain technology. In their study, Wamba et al. (2020) found that trading partner pressure, which they associated with

trading partner technology readiness, as being a driver of blockchain adoption in supply chains. The authors hypothesised that if a supply chain member has a high level of technology readiness, then they are more likely to influence other supply chain members to adopt blockchain technology.

Moreover, Interview Participant 05 notes how in his experience as a Technology Provider, it is very infrequent that he works with Supply Chain Members whom have a high level of digitalisation and data accuracy. He also acknowledges how this may be a specific industry issue as opposed to being a generalisable rule across industries as he states that "companies in the food system don't always work that way [use digitalised systems]. It's paper and a filing cabinet, and that's a very challenging environment for us". This extends on the aforementioned research and provides evidence suggesting that blockchain adoption barriers are industry dependant.

"Yes, the data was already available, the data was already structured, and labelled and organised, and yes. If every client engagement looked like that, then life would be good. Unfortunately, that is in the very small digits of how often that happens" – Interview Participant 05

Notably, this finding was also discussed in a separate interview with participant 12. This is significant as the questions were open-ended and didn't force a specific agenda on to the interviewees as they were free to discuss topics they felt important to the core research area. Interview Participant 12 also had large amounts of experience in the food industry and they also have found that the food industry specifically has large amounts of growers within the supply chain whom use paper-based systems. Similarly, Interview Participant 11A also shared similar findings when working in the food industry. The participant expressed how they often encountered farmers whom did not have access to an internet connection which can impede the ease of deployment.

"It's collection of data which becomes very tricky. Because the farms and each entity along the journey, the maturity of their technology and their understanding is different, right? So, you zoom in and things, and I've seen some farms where they write everything on a piece of paper." – Interview Participant 12

5.1.2. Organisational Barriers

Consistent with Saberi et al. (2019), organisational barriers refers to a grouping of codes which detail the "internal activities of organisations" in relation to the blockchain project. However, one distinction occurs when discussing consultant challenges. In this study, consultant challenges are considered as a subset of the organisational category. The justification for this is that consultants can enact as part of the deployment lead organisation as they are, generally, hired by the deployment lead organisation. Further, the inclusion of governance barriers, as opposed to interorganisational barriers, means that the governance challenges concern the deployment lead and the supply chain members; thus, the consultant challenges cannot belong to the governance category. As a result, consultant challenges are a grouping of codes from the deployment leads perspective, which consider consultant challenges similar to intradepartmental challenges as a result of (1) the closeness of collaboration and (2) the overarching objectives mirroring that of the deployment lead. The remainder of the organisational barriers section is structured according to the seven subsets of the organisational barrier's category within the template analysis.

When aggregating the organisational barriers codes, organisational barriers was the second most prominent category with 314 codes being cited in the interview data. Table 13 details the organisational barriers codes alongside their respective number of total references in the dataset and the number of files where the code appears. Within the organisational barrier's category are the second and third most referenced codes within the entirety of the

data set. These are (1) 'Necessity for blockchain ROI to add value' and (2) 'Lack of blockchain expertise'. Significantly, these occurred in sixteen and fifteen of the eighteen interview transcripts. In contrast, resource challenges, such as financial challenges, were some of the least frequently referenced codes within the entire data set. Thus, this could show that a majority of participants involved in this study did not consider blockchain deployments throughout supply chains as being especially resource intensive.

Table 13: Organisational barrier codes alongside the number of files in which the code appeared and the number of times data was referenced with that code in total

CODE ID	Organisational Barriers	Files	Ref
ORG21	Necessity for blockchain ROI to add value	16	62
ORG18	Lack of blockchain expertise	15	38
ORG22	Difficult to establish the expected ROI	9	22
ORG08	Organisation mindset has yet to fully trust the switch to blockchain	6	16
ORG12	Lack of upper management support	6	14
ORG04	Some 3rd parties don't have the technical expertise they claim to have	5	13
ORG23	Lack of desired ROI within budget period	8	13
ORG06	Blockchain for the sake of blockchain	6	9

ORG38	Cost forecasting inaccuracy	3	9
ORG01	3rd parties can have blockchain platform preferences and biases	4	8
ORG02	Blockchain providers lacking regulatory or industry understanding	3	8
ORG13	Project management approach challenges	2	8
ORG27	Larger organisations have more legal hurdles and bureaucracy	6	8
ORG16	Inter departmental disputes	3	7
ORG09	Risk averse and anti-innovation	1	6
ORG14	Business operations and strategy challenges	4	6
ORG17	Conflict between IT departments and 3rd party consultants	2	5
ORG24	Blockchain not aligned with business goals	3	5
ORG25	Smaller organisations have fewer resources and influence throughout the supply chain	5	5
ORG35	Challenges justifying deployment costs for small suppliers	3	5
ORG03	Poor communication between 3rd party developers	1	4
ORG07	Blockchain for marketing purposes	3	4
ORG29	Product transformations make traceability and data collection harder	2	4

ORG31	Maintenance costs*	2	4
ORG44	Low existing digitalisation	4	4
ORG10	Blockchain currently for early adopters	1	3
ORG28	Large organisations have more stakeholders	3	3
ORG15	Business personnel underrepresentation in the project	1	2
ORG20	Lack of understanding of their supply chain	2	2
ORG39	Technical issues increase costs	1	2
ORG41	Experienced developers are expensive	2	2
ORG05	3rd parties making false marketing claims	1	1
ORG11	The perception that blockchain is new	1	1
ORG19	Improving internal tech competencies takes a long time	1	1
ORG26	Smaller organisations have fewer blockchain competencies	1	1
ORG30	Lack of standardisation between product lines	1	1
ORG32	Supporting technologies maintenance costs	1	1
ORG33	Maintenance as a hidden cost	1	1

ORG34	Customer support costs	1	1
ORG36	Supporting technologies increase deployment costs	1	1
ORG37	Blockchain deployment is resource intensive	1	1
ORG40	Web3 directionality uncertainty increasing maintenance costs	1	1
ORG42	Cost of labour	1	1
ORG43	Difficulties establishing funding when ground up initiation	1	1

The most discussed organisational barriers pertained to return on investment challenges and the value which would be realised by the deployment lead organisation. Perhaps best stated by Interview Participant 12, the overwhelming majority of the interviewees expressed that blockchain technology must address a business need in order to create value for the deployment lead organisation.

"What problem are we solving? What exactly this protocol can do?... Not just technically how good it is, it's is it solving a real problem? Is reaching out to the people or working on genuine problems? Which pain point are you solving right now?" – Interview Participant 12

Similarly, Interview Participant 08 notes how establishing the value which the blockchain solution can generate for the deployment lead is "a very common challenge", denoting that this is an issue which he frequently encounters as a technology provider. This finding is fairly well established within the extant literature and was first proposed in the early paper by Francisco & Swanson (2018) who concluded that the expected value to be elicited as a result

of the blockchain would influence an organisations decision to deploy a blockchain solution. This finding is also evidenced within the literature review portion of Clohessy & Acton's (2019) study. The authors found 'Perceived benefits' [of blockchain technology toward their use case] as being the second most prominent barrier in the extant literature on blockchain adoption. This is also evidenced in the empirical research of Queiroz & Fosso Wamba (2019) who focused on influences as opposed to barriers in their study. The authors combined understanding and expected value into a single factor, performance expectancy. In their study they found that when decision makers expect that the blockchain system will offer tangible value to the organisation, then organisations are increasingly likely to invest resources into the blockchain system.

This finding also extends upon the findings made in the research of Nayal et al. (2021). In their study they were trying to understand the motivations for deploying a blockchain solution throughout an agri-food supply chain. They found that the expected return on investment was the primary driving force behind organisations decision to deploy a blockchain solution. These findings in conjunction may suggest that expected return on investment is both a motivator and inhibitor of blockchain deployments due to the uncertainty in projecting the value which will be realised by the solution. Likewise, expected return on investment relative to the costs of deploying and maintaining the blockchain solution was found to be the third most significant motivator of blockchain adoption according to the survey study of Saurabh & Dey (2021).

Some interviewees extend upon this by stressing that the value which the blockchain offers the deployment lead should be considered in tandem with the budget period and the funding cycles. Interview Participant 06 and Interview Participant 07 each cite distinct examples whereby the duration required to realise the full value of the blockchain was not afforded to the project. This supports the evidence presented by Clohessy and Acton (2019) as in SME instances where resources were limited, Clohessy & Acton (2019) found that the value which blockchain can add to be the driving factor in the decision making to deploy a blockchain; whilst in the cases on large organisations, other motivations were more present.

"But in the ones we could control, reasons for failure was sometimes there's a mismatch in expectation on how long it will take and the value it brings." – Interview Participant 06

Another frequently discussed grouping of challenges were workforce barriers. Most notably, 'lack of blockchain expertise' within the deployment lead organisation was the third most cited code in the entire data set. This is consistent with the extant literature as lack of blockchain competencies features heavily throughout the literary body and is arguably the most frequently discussed challenge pertaining to blockchain deployment. Participant 11B explained that one of the biggest issues which they face as a Technology Provider is organisations "misunderstanding what it [blockchain] actually does". This is concordant with the findings from Clohessy & Acton (2019) who found lack of blockchain competencies as an inhibitor of blockchain deployment in their case study research, even in developed countries. Likewise, this research finds empirical evidence supporting Francisco & Swanson (2018) who hypothesised that the expected effort required to build the solution would be an inhibitor of any blockchain being deployed, as lack of understanding in this study is a broader term which includes factors such as effort expectancy. Lack of understanding was also a code which appeared in the research of Wang et al. (2019) with half of the interviewees discussing challenges related to lack of understanding. However, despite these findings being similar, in this study almost all of the interviewees expressed issues with a lack of understanding. This may be a consequence of the differences between the two demographics of the study as they used supply chain experts with a familiarity with blockchain and IT experts with a familiarity with supply chains; whereas in this study every participant had to have extensive experience working to deploy a blockchain solution throughout a supply chain. Further, this research had a weighting towards technology providers, who assume the role of expert in relation to the blockchain deployment. As a result, they may feel there is a lack of blockchain expertise at the organisations they are brought in to assist. Thus, this would explain why lack of blockchain understanding is represented as a greater challenge in this study than in their research.

In 2019, Zhao et al. (2019) published findings of a systematic literature review of agri-food blockchain journal articles. In their study they found that lack of skills was the 6th most prominent barrier to blockchain technology adoption appearing in the literature. Similarly,

Saberi et al. (2019) also found lack of understanding as a major barrier to blockchain adoption; however, they state how this lack of blockchain expertise is also present in the number of developers which can increase competition for developers with the required technical expertise.

Lack of blockchain understanding was also included as one of the most prominent barriers to blockchain technology, specifically within food supply chains, in the literature review by Duan et al. (2020) and within the literature review study of Clohessy et al. (2020). However, in Clohessy et al. (2020), the authors included organisational readiness as a factor. This included human resources and competence within the organisation. However, it also included financial resources and infrastructural resources. Thus, whilst organisational readiness was found to be one of the most significant barriers, this may reflect it having several multifaceted inputs within their study, rather than it being as prominent as a separate factor as it was in this research. This is also concordant with the research of Treiblmaier et al. (2021). In their mixed methods study, lack of understanding was differentiated into five subcategories, each of which detailed lack of understanding about a specific area within blockchain. Significantly, of the 190 survey respondents, the five different lack of understanding factors were the five barriers the respondents felt hindered blockchain projects to the largest degree, relative to all the other studied factors. This shares similarities with this interview research as lack of understanding was found to be one of the main barriers facing blockchain deployments in supply chains. Likewise, the interview data within their study further emphasises the significance of lack of understanding as a barrier to blockchain deployment. Further, their methodology permitted insights into divergences between start-up and incumbent organisations and whilst several barriers are exacerbated or mitigated in the two accounted for types of organisations; lack of understanding remained a significant challenge in both of the studied samples. This is significant as the presence of this finding occurs with similar levels of prominence in two of the largest interview studies, as well as being evidenced as the most significant challenge within their survey data, within the blockchain domain.

In some ways this finding is also concordant with the findings of Van Hoek (2019). In the survey section of the authors research, various different dimensions of lack of understanding were found to be the 7 most significant barriers to blockchain adoption in

supply chains. Van Hoek differentiated between specifics where lack of understanding could occur. Despite this, the vast majority of the lack of understanding codes were the most frequently cited by the surveyed demographic. Whilst the finding of the prominence of lack of understanding is concordant, it appears at a significantly higher rate within van Hoek's study. This could be indicative of lack of understanding of blockchain technology improving over time. Alternatively, this may be a consequence of the study involving a sample where those surveyed were not experts in the field of blockchain technology, or individuals who have experience working to deploy these solutions. Thus, it may be expected that in using a sample with less blockchain expertise, that lack of understanding issues would become increasingly prevalent. This is supported in the comments made by interviewees 02 and 08. Interview Participant 02 reasons that this lack of understanding is prominent as a consequence of the infancy of blockchain technology; with other participants, such as Interview Participant 08, also suggesting that this will be alleviated overtime as the technology matures and becomes more accessible. Thus, several interviewees recognise the infancy of the technology as a condition which can cause a lack of understanding in the deployment lead organisation. However, this is discordant with the conclusion of Clohessy and Acton (2019). Despite similarity in finding of blockchain understanding as an inhibitor, Clohessy & Acton (2019) cite the underlying cause of this being resource-based as they state lack of blockchain understanding correlated with the studied cases where resources were fewer. These findings in conjunction may suggest that lack of blockchain understanding is multifaceted in its rooting. However, infancy of technology as an influencing variable on blockchain understanding is documented in the work of Wang et al. (2019). The authors found that blockchain infancy was related to lack of understanding in their study; however, this data collection shows that even after five years of the technology maturing, blockchain understanding is still limited. Thus, this research extends their finding to a later date which is significant given that the technology has matured between the two dates of data collection.

"First of all I'll preface it with the majority of enterprises that are coming into the space, even today, are still very new to blockchain technology. In many cases I've had conversations with customers that have not even touched Ethereum before and are still deciding do they want

to do Ethereum or do they want to go with Hyperledger Fabric or what-not." – Interview Participant 02

Similar sentiments were discussed in the interview with Interview Participant 04 when discussing an instance where he worked as an advisor to help build a blockchain throughout a beef supply chain. In his experience, he initially allowed the IT department to attempt to build the blockchain solution; despite noting they "didn't have the skills" in this area. However, ultimately as a result of their lack of experience with blockchain technology, they were unable to build a working solution and this caused a large financial outlay and delayed the project by up to three months. However, interview Participant 04 cited 'shame' as the underlying causal mechanism which caused the IT department to attempt to build the solution without outside aid as he felt that they felt ashamed that they didn't understand how to build a blockchain solution.

"We did have a problem with the tech because the IT department, because they're the IT department and they're meant to be experts, [they] thought they could build it. I wasted three months and $100 000 proving to them that they couldn't. They don't have the skills, didn't have the technology stack, didn't know how, didn't know how to do anything." – Interview Participant 04

Interview Participant 15 extended on the aforementioned discussion by stating that lack of understanding of blockchain technology is in itself a causal mechanism that prohibits the ability to design a blockchain solution which can elicit a good return on investment for the deployment lead and the supply chain.

"So, I feel that understanding is still quite wrong and people are not able to design a proper use case which gives them value. So this is where understanding is the main problem." – Interview Participant 15

Another issue relating to the workforce was in upper management support; however, this seemingly manifested itself in a multitude of ways. Interview Participant 10 stated that "it [blockchain deployments throughout supply chains] starts and finishes with management support" showing that he placed great emphasis on the importance of establishing upper management support when seeking to deploy blockchains throughout a supply chain. Similarly, Interview Participant 06 noted that in projects where there is an absence of upper management support, the project has an elevated risk of failure, implying that upper management support can be crucial for overcoming various adversities which may occur throughout the project.

"But others are not like that. You need to, I'd say, figure out if a company at the C-level suite, as support for blockchain implementation. Otherwise, it's going to be much more risky." – Interview Participant 06

In the case study portion of their research Clohessy & Acton (2019) found upper management support was prominent in each of the cases where blockchain had been successfully deployed, leading to them concluding that the need for upper management support was one of the three most consistent findings from their research. This was cited as being a causal mechanism which enabled greater quantities of resources to be allocated to the projects. Likewise, lack of top management support was also a reason given by organisations who had not deployed blockchain solutions. This is further supported Saberi et al. (2019). In their conceptual paper on blockchain challenges, the authors included financial challenges as one of their seven intra-organisational challenges. However, they state that this is underpinned by upper management support. Thus, this implicates that in circumstances where upper management do not back the blockchain project, it is less likely to receive sufficient funding. This finding was also made within the Kouhizadeh et al. (2021) survey study which also used the TOE theoretical framework. However, in their study, lack of upper management support was found to be the most prominent organisational barrier by both academics and practitioners. Thus, whilst it was still an issue within this study, it is of much greater relative importance in the Kouhizadeh et al. (2021) research. This

divergence may reflect methodological differences between the two studies, such as the different modes of data collection.

One more unique discussion of upper management support occurred with Interview Participant 01. He found that the upper management was a hindrance to the project in some ways; despite supporting the project. This was a result of the project management style which was imposed on the project by upper management as he wanted a waterfall project management approach, as opposed to the interviewees preference of an agile project management style.

"*So, rather than starting with a small assumption and building from there, implement some things, does it work, etc. It was very much a case of let's build this out, this massive specification that involves, let's say, ten different partners all having to integrate and running into issues and basically, yes, well we expected this*" *– Interview Participant 01*

Numerous interviewees also noted how disputes can occur between the departments within the deployment lead organisation and the external technology providers and consultants which are brought in to aid in the project. Interestingly, of the codes relating to consultancy challenges, the most discussed pertained to the consultants' lack of understanding. Thus, lack of understanding codes permeate the deployment leads, the technology providers, and the consultancy organisations. However, with the technology providers this seemingly manifests in a variety of ways. Firstly, like the lack of understanding discussed previously, the technology providers can make claims about their blockchain competencies which are untrue as a means of securing consultancy work. As Interview Participant 02 notes, this can cause the blockchain projects to never be realised as issues end up occurring which the technology provider is not equipped to solve.

"But then again there are a lot of shops out there too that claim they have the expertise and then win the contracts and then they really don't and they can drag the project down and actually lead some of the projects to failure." – Interview Participant 02

Likewise, Interview Participant 09 has observed similar claims being made by technology providers to secure contracts; however, she notes how this is especially common when working with start-ups. Secondly, some technology providers, whilst they have the technological capabilities needed for the project, they lack the required industry and regulatory understanding to deliver the project. One given example of how this can manifest itself is in standards not being used to refer to a product, and then confusion can occur as the product moves between organisations and geographies as the identifier does not accurately correspond to the product.

"Typically, these blockchain companies are illiterate with regard to the regulations that they need to comply with if they're offering a solution. Let's say they're offering a solution in the US. They would typically not have a deep understanding of US regulations." - Interview Participant 10

Lastly, several interviewees expressed how technology providers often have motivations or biases which cause them to want to build the blockchain using a specific platform – which is not necessarily the best fit for the project. Notably, Interview Participant 01 acknowledged that he pitched using a certain platform to a client because his organisation wanted to build up their internal competencies with that product. However, he did caveat that he believed it was coincidentally the best platform for the project. Interview Participant 10 referred to organisations who hold these biases as technologically 'religious zealots' whereby the technology providers are familiar with a specific platform and as a result, force that platform onto the project instead of evaluating other options and selecting according to suitability.

"That religious category means that, oh, I'm a Microsoft expert so I have a Microsoft religion, or I'm an SAP expert so I have the SAP religion. If you come to them and if you're a Catholic or a Protestant or Jewish or atheist and somebody is trying to change your religion, I

know what you're going to say. I know what I would say to them. That's the problem that we have. That's a major problem." – Interview Participant 10

One grouping of issues which were raised throughout the interviews with several participants involved the mindset of the individuals at the deployment lead organisation and how mindset can inhibit the blockchain deployment. These codes were organised into two categories – (1) attitudes and (2) motivations. Namely, various participants expressed how they see a lot of projects which are started for reasons which they considered to be incorrect. For example, Interview Participant 09 had worked with a company which were seeking to deploy a blockchain solution. They had invested a lot into press-releases regarding the blockchain and were using it as part of their marketing strategy. However, she has since seen that the employees involved in the project are no longer a part of the project and that there is no mention of the blockchain in any of their press releases or in their company documentation which she believed was because the blockchain project was created for marketing purposes rather than being business driven.

"I was doing some research and looking back and I wanted to learn more about it and I reached out to the company. And there was no documentation. All of the people involved in the project were gone and there was no written documentation left in the company. Which tells me that while they put a lot of PR resources behind it, it wasn't really integrated into their business model. It was more a fun PR piece. And in a lot of ways, what a waste of resources." – Interview Participant 09

In the Clohessy & Acton (2019) study, large organisations were more likely to be involved in blockchain and were less likely to cite the functionality improvements as the reason than the SMEs. Thus, their study suggests that resources are a more significant driver in determining if an organisation will be able to deploy the solution, suggesting that the wrong motivations are not a great inhibitor of deployment. This is supported in this study as whilst several interviewees expressed concern over motivations, it was not one of the most

prominent barriers within the study. Similarly, Interview Participant 08 stated that "Technology for the sake of it is probably the worst thing that you can do to the industry. You really need to see that the problem that you are trying to solve" whilst Interview Participant 02 also commented on blockchain being used as marketing tool when it wasn't necessarily the best tool for addressing the business needs. Interview Participant 17 extend on this by explaining how in order for the project to be sustainable long term, there is a need for the blockchain to provide a user or business benefit. However, conflicting with previous interviewees, he felt that it was acceptable for organisations to explore blockchain technology for the wrong reasons so long as they eventually established some value from the project. Thus, he felt like the project could evolve over time into a sustainable project even if it originated as a marketing project.

"In the beginning usually people or companies join because it's cool to be part of a blockchain project. It's also a lot of times sponsored by the innovation team. But this must also be sustainable in terms of it must give some user or business benefit, or both, at best, for the company to really be onboard, stay onboard and also delivering the required data to trace certain things" – Interview Participant 17

Another motivational issue with blockchain projects which some interviewees commented on was when blockchain projects are pushed by the innovation team with the objective of being innovative. Interview Participant 05 spoke on how this was a common motivation back in 2017 and 2018; however, he did also caveat that he believed organisations were switching to being more driven by the business problem which they aimed to solve more recently.

Some interviewees also discussed the risk averse nature of organisations, even when they are attempting to be innovative. For example, Interview Participant 02 discussed how the community governance model which he defined as "the true thesis of blockchain" is something which organisations find too foreign from their current modes of working.

"If you look at the true thesis of a fully decentralised network, it's going to make most enterprises allergic to begin with… The panacea there is it's all smart contract based, as DAOs are today, but if you mention a DAO to enterprise, especially an enterprise regulated, they're going to tell you to walk out the door because that's just too scary and spooky for them." – Interview Participant 02

Additionally, Interview Participant 05 says that a large portion of the organisations which he provides with blockchain technology do not use that technology as the sole data management system. Instead, they prefer to use the blockchain in parallel with a legacy system. As a result, a lot of his clients are risk averse in that they do not trust the blockchain system to operate as their sole data management system, despite the desire to explore innovative technologies.

"A lot of companies that we work with run our software in parallel to how they do what they always do, so that they may be doing two times the work or one-and-a-half times the work. They've not been confident enough to make the full switch for a variety of reasons". – Interview Participant 05

These findings in tandem suggest that a significant quantity of organisations have yet to trust the switch to Web 3.0 technologies and are instead operating with elements of Web 3.0 and Web 2.0 systems. This finding is consistent with a finding from a study which was looking into drivers of blockchain adoption. Using a wider definition of attitudes that describes an individual's reaction to technology, Kamble et al., (2019) found that attitudes positively impact the likelihood that they will action a deployment of a blockchain solution. Alternatively, this study found that where the attitudes are negative, this may dissuade or impede the deployment of the blockchain solution. A similar finding was made within the survey study of Kouhizadeh et al. (2021). Their research found 'hesitation to convert to new systems' was the second most significant organisational barrier. However, they go on to state that this is a consequence of the lack of understanding causal mechanism within their

research. The increased prominence of this finding in their study, relative to this study, may be a consequence of the different selection and sampling approaches employed between the studies. In this study, it was a requirement that all participants have deployed a blockchain solution; whereas, in their study not all participants met this criterion. Thus, risk averse attitudes would be expected to be more prominent when using a sample who have not all deployed these solutions. The statements of interview participant 05 may extend and be consistent with a finding made by Saurabh & Dey (2021). Trust is a factor which is studied within the Saurabh & Dey (2021) study. They find that trust in the blockchain increases the likelihood that blockchain will be adopted. They find trust to be one of the weaker levels of influence over blockchain adoption of the factors studied. However, it must be caveated that they seemingly use the term trust to refer to trust between organisations, and trust between organisation and blockchain technology. Thus, it isn't explicated what specifically they are observing. As a result, the discernibility of this finding being consistent with this research is inhibited.

One notable finding pertains to financial challenges. Specifically, the lack of prominence of these codes within the template and their omission within a significant quantity of the interview transcripts. This is significant given the open-ended phrasing of the interview questions as this affords the interviewee the opportunity to raise issues which they have experienced first-hand. Further, a large portion of the participants chose to discuss factors other than financial issues; showing they are not one of the largest issues facing blockchain deployments amongst the interviewees in this study. However, some interviewees did stress their significance, with Interview Participant 14 stating "Well, frankly speaking, the problem is always money. It's money". This may be explained by Interview Participant 11B who reasoned that the costs associated with POCs and Pilots are low; whilst the costs associated with production grade deployments are much higher. This in conjunction with the majority of projects not being in production, could explain this finding. Conflicting, a significant number of the interviewees have worked on production-grade blockchain projects so if this was a factor then it would be expected that it would appear more prominently in other interview transcripts.

"A pilot's not expensive, like a pilot really isn't that expensive. But once you go into live production, with real users, you need customer support, you need all those different kinds of things. As opposed to a proof of concept of maybe 100 people that you can hand-hold through the process. It's that. It's like building enterprise software is expensive. It needs to be autonomous, it needs to be robust, it needs to be available" – Interview Participant 11B

This is concordant with the findings of Clohessy & Acton (2019) who found that in their studied cases where a blockchain project was occurring, financial challenges were not cited as being a barrier. However, their study indicates this occurred for two main reasons: (1) In their included sample, in a majority of instances where blockchain projects were present, the organisations were classified as large organisations. (2) The authors referenced upper management support as being a consistent underlying factor which was present in each case where a blockchain project was occurring. However, this finding is discordant with the findings of Wang et al. (2019) who found that of the interviewees studied, costly implementation was one of the most present codes. However, they do note how there was a disparity in views between their participants regarding how costly blockchain deployments are, with several interviewees believing costs are a less significant challenge than others. This is also conflicting with the extant literature on blockchain in agri-food until at least 2019. Zhao et al. (2019) performed a systematic literature review of blockchain adoption literatures in agri-food and they concluded that running costs were the 5th most significant challenge facing blockchain technology and that this was a consequence of the underlying causal mechanism of high energy costs associated with blockchain technology. This may be a consequence of the technology maturing and running costs reducing overtime. Alternatively, this may be due to their research methodology being indirectly influenced by the cryptocurrency literature as despite not including cryptocurrency literature within their article, some of the studies they do include have included cryptocurrency which could allow this influence of a different use case to be present within their findings. Further, the survey research within Van Hoek (2019) also contrasts financial challenges being insignificant as is shown in this study. In their study, they found the costs associated with blockchain deployment were the most significant challenge facing the technology, outside of understanding of the technology. This may be a consequence of the studied sample not

requiring expertise in blockchain or experience with blockchain deployments in supply chains. This is supported by how in the case study section of the authors research, he found that none of the involved organisations found costs to be a significant issue, with the projects being described as “inexpensive” and “very affordable” (Van Hoek, 2019, p844). Though, these projects were all pilots so costs would be expected to increase as the solution entered production. Thus, the large-scale qualitative studies into inhibitors to blockchain throughout supply chains do not find financial challenges to be a significant issue; whereas quantitative and literature review studies suggest financial challenges are very significant for blockchain deployments. This could be evidence of methodological biases influencing the type of data which is collected. Similarly, this finding can also be observed in the Kouhizadeh et al. (2021) study. The authors found that financial constraints were found to be of low significance, relative to the other factors measured in their study, suggesting that blockchain adoption is relatively inexpensive. However, they do note that this may be a consequence of potential biases within their data analysis methodology.

Contrasting this trend between the methodologies, Treiblmaier et al. (2021) conducted survey research into blockchain adoption barriers in the agri-food sector. They found that a dedicated budget is needed. Their research methodology permitted insight into divergences between start-ups and incumbent organisations. Notably the sourcing of funds is very different in start-ups as they tend to rely on external sources of cash, whilst incumbent firms rely on internal funding. Incumbents are also more reliant on managerial commitment whereas this is a feature which is usually already there for start-ups. Their research finding is significant as it provides evidence that subsequent researchers should attempt to differentiate between the two types of organisations, where discussing financial constraints. This also may explain how in this research financial challenges were not prominent as none of the interviewees discussed blockchain in the context of a start-up; and as result the findings of Treiblmaier et al. (2021) would predict financial challenges would be expected to be less prominent.

Despite financial challenges not being heavily discussed by the interviewees, financial uncertainty was the most discussed financial challenge. As outlined by several interviewees, it can be difficult to accurately forecast expected costs for a variety of reasons. Interview Participant 14 explains that technical issues, security issues, and network issues can each

lead to an unexpected increase in costs. This is supported by the findings in one of the cases included in the Clohessy & Acton (2019) study. In that case, hidden costs were cited as being an inhibitor of the deployment.

"Honestly, the only problem that I see at this time is in general your costs are raising because there are technical issues, security reasons, network reasons and so on. And you are facing the real world so it costs you money because you have no very realistic projection." – Interview Participant 14

Alternatively, Interview Participant 02 notes how the directionality of the blockchain space can impact costs in unforeseen ways. For example, he states how advancements in public blockchain platforms could offer a greater level of value to the supply chain use case than private blockchains can in the future. As a result, organisations may need to invest into public blockchains after already having established a production grade private blockchain. This investment, which is not guaranteed to be needed, would present significant costs for the supply chain in order to bridge the data onto the new network. Issues concerning private and public blockchains are discussed in greater detail in Section 5.1.3 Systems Barriers.

"Think of it as a hybrid between public permissionless and private permission. That will happen over the next two to five years. So, these existing networks have to grapple with is that going to come to fruition and when it does, how do we evolve these networks? Do I have to completely throw away this network, will companies like Blockchain Software Provider provide bridging so I can have this private permission that worked and bridged to these other networks? These are all questions that we're ruminating through and answering right now and trying to develop them." – Interview Participant 02

Another cost which is specific to blockchain is workforce costs. Some of the participants explained that blockchain developers have large salaries. Interview Participant 15 explained

how this is a result of a “shortage of supply” of blockchain developers with the required technical expertise. Similarly, Interview Participant 14 has observed high labour costs; however, he continues by acknowledging that this may vary based on the geographical location of the project and as a result, is not necessarily generalisable to every scenario. This finding extends on the work of Saberi et al. (2019). The authors stated that there is a lack of expertise in blockchain technology; however, these findings on conjunction suggest that over time this technical expertise is improving, but that it is weighted towards specific blockchain platforms.

“When you are talking about skills, yes, it can be a problem because skills are quite expensive and you are obliged to go outside because within a company it's very difficult to have the right skills or you don't have enough people. Then it begins to move a little bit, the problem is like the competencies and the skills are very rare and so the cost of a CTO, for instance, in blockchain is, at least in France, but I guess in UK, very high”. – Interview Participant 14

5.1.3. Systems barriers

Systems barriers are a set of technology focused challenges which includes the technological aspects of the blockchain system and all of the additional technologies that support the blockchain solution. Thus, consistent with the works of Saberi et al. (2019) and Kouhizadeh et al. (2021) this context includes issues relating to technical immaturity, complexity, and security, but as a result of abductive inferencing it also includes issues concerning data, specific functions, and system design decisions. This is achieved through the division of systems barriers into three categories – (1) Functionality challenges, (2) Data collection challenges, and (3) System decision challenges. Each of these three categories forms the basis of the structure of the remainder of this section.

Table 14 shows a list of each of the systems barriers assorted by the number of total times an excerpt of data was coded with a specific code. Of the systems barrier codes, the three

most prominent codes are each belonging to a different category; showing the multifaceted nature of systems barriers.

Table 14: Systems barrier codes alongside the number of files in which the code appeared and the number of times data was referenced with that code in total

Code ID	Systems Barriers	Files	References
SYS02	Lack of standardisation between partners	9	24
SYS13	Blockchain accessibility and interactability	9	23
SYS33	Indecision between blockchain platforms	11	22
SYS14	Blockchain still in a state of relative infancy	8	22
SYS03	Collecting fraudulent or inaccurate data	8	20
SYS23	Integrating blockchain with legacy systems	8	19
SYS09	Blockchain objective specific challenges	7	16
SYS04	Difficulty collecting absolutely assured data	5	14
SYS15	Data security issues	5	14
SYS24	Integrating blockchain with the technology stack	5	12
SYS11	Data collection is product specific	6	11

Code ID	Systems Barriers	Files	References
SYS10	Industry specific challenges	6	10
SYS26	Indecision between public or private blockchain	6	7
SYS25	Blockchain interoperability	5	7
SYS34	Blockchain update challenges	4	7
SYS16	Smart contract challenges	5	6
SYS05	Manual data collection challenges	4	6
SYS17	Transaction throughput speed	3	5
SYS18	Tokenisation of digital assets	3	5
SYS21	Introducing supporting technologies increases complexity	3	5
SYS06	Data collection from network partners	4	4
SYS29	Private blockchains don't scale	1	4
SYS30	Private blockchains offer less value than public	1	4
SYS07	Blockchain requires a lot of points of data collection	3	3
SYS27	Private and public blockchains present different challenges	3	3

Code ID	Systems Barriers	Files	References
SYS35	Potential need to switch to a new blockchain in the future	3	3
SYS12	3rd party certification challenges	2	3
SYS22	Infancy of supporting technologies	2	3
SYS36	Blockchain platform resource challenges	2	3
SYS19	Lack of standardised maintenance of technology	1	3
SYS01	Data collection challenges*	2	2
SYS32	Public blockchain security issues	2	2
SYS08	Syncing the digital data with the physical assets	1	2
SYS20	Payment rail challenges	1	2
SYS31	Private blockchain data security issues	1	2
SYS28	Private blockchain challenges*	1	1

In contrast with the Governance codes in Table 12 and the Organisational codes in Table 13, despite systems barriers having a similar number of total codes, the specific codes feature with less frequency in the number of transcripts where the codes appear. For example, the most referenced code 'Indecision between blockchain platforms' only appears in 11 of the 18 files; whereas the most prominent governance barrier code, 'Lack of incentive to join the network', and the most cited organisational barrier code, 'Necessity for blockchain ROI to

add value', appeared in 17 and 16 of the 18 transcripts respectively. Thus, this could suggest that systems related barriers are still significant, but that they have a greater level of variation in how they occur between instances. This would make any findings concerning systems related barriers less generalisable to generic cases.

In terms of functionality challenges, by far the most widely discussed were challenges concerning integrating the blockchain solution with the wider technologies. This included, integrating the blockchain with legacy modules, the novel technology stack which is supporting the blockchain, and ensuring the blockchain is interoperable with other blockchains within the network. This is in contrast to the findings of Biswas & Gupta (2019) as this research found integration challenges as the most prominently raised technological issue by the respondents; whereas their research found technological scalability challenges as the most significant causal barrier to blockchain adoption. This finding is also discordant with the predictions of Saberi et al. (2019) in their relevant conceptual paper. The authors reviewed the extant literature to develop a list of challenges, and then had these reviewed by experts in academia. Significantly, integration challenges were not an included challenge in their list, despite including over twenty different categories of barrier. This may be explained by the warping of their findings due to the cryptocurrency literatures which were included as inputs in their literature review. Blockchain interoperability was also cited as being a challenge facing blockchain deployments in the research of Wang et al. (2019). However, their coding system does not permit insight into how many interviewees found blockchain interoperability a challenge and the included quotation was speaking hypothetically about challenges they would expect to incur when deploying a blockchain system. Thus, this research extends this finding by providing first-hand accounts of situations where blockchain interoperability and blockchain integrations have been a challenge. In this study, legacy systems were discussed as being especially difficult to integrate with for several reasons. Interview Participant 05 stated that one cause of this is due to the complexity and size of the legacy systems. He noted how because of the scale and complexity of the legacy systems, they sometimes also need to collaborate with an organisation who specialise in integrating blockchain solutions with legacy systems.

"That [integrating] is difficult, because now you're dealing with people like SAP, you're dealing with people like Oracle, Microsoft, and these are big, complicated systems. Most often, third parties have been hired by the organisations to implement these systems, then we have to deal with their third-party consultant to do the integration. And that is very, very challenging." – Interview Participant 05

Similarly, Interview Participant 06 cited a case where they were hired as a blockchain technology provider to build and implement the blockchain and the additional technologies for a deployment lead. In this case, one of the collaborating organisations was using a combination of three different ERP systems, one of which was a bespoke in-house solution. In this scenario they found that one product which was referenced in each of the ERP systems was associated with a different name within each module and as a result, this greatly increased the complexity of the solution as their legacy systems were not currently compatible with each other. Thus, in this instance the deployment of the blockchain was impacted by the state of the data, as well as the legacy systems which store the data, which both increase the complexity of the deployment.

"We had a client that had a mix between Multinational Software Company and Large Multinational Tech Organisation modules, and their own inhouse built module, and it was a nightmare. Because those modules, even within the same client, they were talking about the same entity, the same quantity of food, with three different names." – Interview Participant 06

Alternatively, multiple interviewees had observed integrating the blockchain with the supporting technologies which capture the data as being an issue. Interview Participant 02 found that, specifically Internet of Things technologies can be difficult to integrate with a blockchain due to IoT and blockchain both still being "relatively new". Likewise, Interview Participant 05 had worked on cases where IoT sensors which fulfilled the objectives of the blockchain had not been developed and as a result, they had to develop what he coined a

"first-of-a-kind" solution which greatly increased the complexity due to the degree of customisation required to build the supporting technologies. Integration challenges were also a significant predicted barrier in the survey research of Van Hoek (2019). However, this finding was discordant with the case study portion of the research. Van Hoek (2019) reported no significant integration issues in any of the three cases. This is significant given that one of the cases was using blockchain as a means of integrating the existing systems. However, the interviewee did explain that they are expecting integration issues in the form of blockchain interoperability as they progress from a pilot to a production grade blockchain. Their finding suggests that integration challenges become more prominent as the solution scales; however, the comments by participants 02, 05, and 06 each acknowledge significant challenges which may occur early within the project demonstrating empirical evidence that integration issues can be prominent at each stage of the project.

"But adaptors into traceability software for food and ag, specifically for bananas? Those adaptors do not exist, because these are sometimes first-of-a-kind integrations. And that's a very heavy lift, and we find that's one of the elements that slows down that big scale-up and wide adoption." – Interview Participant 05

Several participants also discussed how the infancy of blockchain technology was itself a barrier to the deployment of blockchain solutions throughout supply chains. Some interviewees referenced the same example of blockchains maturity being in a situation that is "*sort of like internet in its early days" (Interview Participant 11B)*. However, Interview Participant 08 does acknowledge that as blockchain technology and the supporting technologies mature, data collection from a technological standpoint will get progressively easier. Notably, he felt like the industry is two-to-three years away from reaching this point. This finding extends upon the findings of Hastig & Sodhi (2020). In their thematic analysis of the extant literature, the authors found that infancy of blockchain technology was a barrier to blockchain adoption. Citing the work of Patrick (2018), they also draw a correlation between the infancy of the technology, the value that the technology can offer, and the risk associated with deploying the technology. They state that infancy of the technology may be

an underlying causal mechanism which inhibits the value which can be realised by adopting blockchain technology. This is then evidenced by the number of managers adopting blockchain technology. They continue by stating that managers may currently see the risk of investment as greater than the potential benefit of competitive advantage.

"So maybe data collection might become a problem in its current form and shape today. But like I said, the technology itself is evolving. I don't know if it's going to be that way in another two, three years. But we have come a long way. From the ETH Merge and all those things that have happened in the blockchain space, we have come a long way. I think we are moving to more sustainable, more efficient consensus mechanisms in the public blockchain networks as well." – Interview Participant 08

One frequently discussed functionality challenge was establishing a user-interface which was accessible and enabled effective engagement from the users. Interviewee 09 signified that there are two important questions which must be addressed in making an accessible blockchain solution – 'How do we design the system? And what are the interfaces?'. Thus, accessibility challenges can occur in designing the system as well as in the practical building of the user-interfaces. However, the majority of respondents focused on the system design decisions as opposed to the technical issues which may occur in building the technology. Further, the majority of the interviewees worded these issues in the positive by stating that you need to design the system to be accessible, implying that if you don't then the system will incur difficulties; as opposed to stating that it is difficult to design an accessible and user-friendly system. In terms of system design the technologies which are being used must be accommodating of the circumstances of the supply chain member. For example, Interview Participant 12 explains how options such as voice recognition, and mobile phones must be considered whilst Interview Participant 02 states that an app may be the most appropriate method to interact with the supply chain. Interview Participant 10 goes further in stating that the user-interface must be designed in accordance with the specific conditions which will impact the user. For example, the participant has experience in working with farmers in a South-East Asian Country where the end user may be illiterate

and/ or may not have access to specific technologies; as a result, the blockchain interface needs to be designed in a way which can accommodate these conditions which will be unique to the context of each supply chain. In a study looking into drivers of intention to adopt blockchain throughout supply chains as opposed to looking at barriers once a blockchain project has begun, Wong et al. (2020a) found that perceptions of system functionality and how accessible the system is to interact with, which were inputs into complexity within their model, can negatively impact an organisations decision to deploy a blockchain. Further, they found that upper management are not likely to support the project if it is increasingly complex. This eludes to a mindset where if the technology is perceived as being difficult to successfully implement, then it is less likely to be attempted. This is consistent with the literature on the adoption of various technologies in operations and supply chain management. However, research by Vasseur and Kemp (2015) has shown that familiarity with innovations can reduce the perceived complexity. These results together suggest that the knowledge and experiences of an individual/ collective can be a large determinant in adoption. Similarly, this finding was made in the Yadav et al. (2020) study. The authors found that 'Complexity of blockchain-based system design' was a causal mechanism which influenced several other barriers. Most significantly was the influence it had on security and privacy concerns. Thus, their study suggests that the complexity of the system directly influences an organisations perception of how secure their data is when using the system.

"So, the challenge that we have in the project in South-East Asian Country is how do we democratise the technology? It will be blockchain, but how do we democratise that? How do we create that frontend where we have someone who is illiterate but can look at shapes and is getting better at reading thanks to the app, but they're largely uneducated." – Interview Participant 10

Data collection challenges were also discussed frequently throughout the interviews. The data collection code is differentiated into two sub-codes – (1) Data accuracy challenges and (2) Circumstantial data collection challenges. Data accuracy challenges contains codes which

pertain to the difficulties in establishing a dataset which can be considered to varying degrees as true. Alternatively, Circumstantial data collection challenges detail how data collection can be affected by three factors – (1) the product the blockchain is collecting data on, (2) the objective of the blockchain, and (3) the industry which the blockchain is operating in. 'Lack of standardisation of data between partners' was the most referenced code within the Systems barriers category. The lack of standardisation of data is a code which detailed instances where a product or piece of data would be either formatted or detailed differently between supply chain members. Interview Participant 12 cites an example where:

"I have, very interestingly, we were working on a project on a seafood. A particular fish was called… Let's say they are catching the fish in Caribbean and they're transferring the fish to Europe. The fish was called by different names in different entities. So, tracking those, somebody calls it the Latin name, somebody calls it the local name. So, making sure there is a library that is, are we talking about the same product?" – Interview Participant 12

In this instance, this created confusion between the trading partners and the technology providers; however, the lack of standardisation of data can also mechanise itself in different ways. Several interviewees expressed the importance of communicating in a universal language of standards between the supply chain partners as a behaviour which could minimise confusion between partners. Interview Participant 09 summarised how the lack of standardisation of data between partners can lead to a series of siloed systems, acknowledging lack of standardisation as a causal mechanism which can inhibit integration.

"This is where things like the GS1 EPCIS standards are so important. Because, if we're not careful, we'll end up with a whole bunch of siloed systems that then can't communicate to one another. And that's going to cost a lot more for companies to share the data around doing business with one another. Whereas if they're using the same standards, like GS1 EPCIS or something by BSI, that's going to enable them to communicate more efficiently across blockchain and non-blockchain platforms." – Interview Participant 09

The lack of standardisation of data was also detailed as being an underlying causal mechanism of integration issues by Interview Participant 06, presented earlier in this section. Similarly, when discussing a series of open-specifications in the telecommunications industry, Interview Participant 01 stated that these specifications are still open to a degree of interpretation which can cause variance between collaborators in how they define the data. This is significant as using standards to structure and name the data is still a solution which requires accuracy in the interpretation of the standards; especially in instances where they are complex. Further, consistent with the beliefs of Interview Participants 06, 09, and 12, this disagreement in interpretation can manifest when attempting to integrate the blockchain with the system of the collaborator. This exact point was echoed by an interviewee within the Wang et al. (2019) study who stated that due to the abundance of different and competing standards, it can be difficult to design a blockchain network which is connected and can account for the divergences in how the data is stored between network partners.

"There's a set of specifications around describing telecommunications resources that is defined by Multinational Professional Services Firm. They're one of the bodies, like a compliance and governance body in that sector, and they have a bunch of open specifications as to how to specify all these sorts of things and I think it would be fair to say that they're quite complex but also not very well understood by the people that are using them" – Interview Participant 01

Another data accuracy code which was heavily discussed in the interview transcripts was 'collecting fraudulent or inaccurate data'. As stated by Interview Participant 15, the value of blockchain is dependent on the accuracy of the data which is being collected, and as a result, it is necessary to be able to trust the data which is being collected. Similarly, Wang et al. (2019) also observed in their interviews that their interviewees warned of difficulties in establishing an approach to ensure the data which is being collected is accurate.

"So most of the time the challenge is that data doesn't exist today. So that is one of the fundamental things that blockchain is not going to solve for you. It needs an input and it depends on that input. It depends on how pure that input is." – Interview Participant 15

However, several interviewees note that the trust in the data, and the value which can be gained from the data, can be diminished by fraudulent behaviours of bad actors and lack of competence in the data collection process. When discussing a track and trace blockchain, Interviewee 04 states that issues occur when attempting to authenticate that the data is an accurate digital anchor to the product which is moving through the supply chain. This finding is similar to one made by Hastig & Sodhi (2020). Data security was one of the inputs into technology readiness within their study. They authors found that data security was one of the critical success factors which needed to be present in order for blockchain technology to be successfully deployed. Security challenges are also one of the most significant barriers found in the survey study of Kouhizadeh et al. (2021). In their research, the authors found that security challenges was one of the most significant challenges within their technological barriers. They stated that security challenge acts as a mediating variable, due to its influence over other barriers such as the 'negative perception towards the technology'. Thus, security challenges needed to be addressed in order for blockchain technology to be viewed more favourably by stakeholders. Further, their study revealed that technological barriers should be addressed first, as tech barriers being addressed is expected to address supply chain barriers. In this view, the solutions to the technological barriers would be expected to solve some of the supply chain barriers. These findings in conjunction show the significance of security challenges within their study as a technological challenge which should be addressed early, within a category of codes, technological barriers, which all need to be addressed early. However, these findings are based on perceptions of blockchain technology in industry and academia. This is significant as the authors observed several divergences in responses between the academics and the practitioners. Analysis of the practitioners showed technological challenges to be most prominent whilst academics believed they were less prominent. Thus, this research is more consistent with the academics in Kouhizadeh et al. (2021), despite the interviewees in this study being from industry backgrounds. This may be explained by the time period of data collection as the technology is developing quickly.

Alternatively, this may be evidence of the interviewees lived experiences not necessarily reflecting the experiences of the majority. However, it is worth considering that the technology providers do all have experience working on many blockchain projects, which would be expected to minimise the latter.

"And people who live in the margins and who trade illegally with food, which happens a lot. 28-day Aberdeen Angus steak which were not. A very common problem. And that's because you can't authenticate them, so people brand it and label products, no one knows whether it's true or not. Often, I'm afraid, it's not true." – Interview Participant 04

Alternatively, fraudulent behaviours can occur when collecting data from a network partner. Interview Participant 06 discussed the role of integrity-based trust in the relationship between the deployment lead and the supply chain member when the supply chain member is providing data first hand to the blockchain as in this case, blockchain being immutable is a null factor as the initial data may have already been tampered with. This is an issue which Wang et al. (2019) also observed in their early interview study. The authors found that some of the interviewees acknowledged that when there is a period prior to storing the data on the blockchain, where the data could be manipulated or where data is entered manually, then there is the opportunity for unethical actions.

"Trust. Which is, can I trust the partners to provide me some data that are correct and not fraudulent?" – Interview Participant 06

Interview Participant 10 has large quantities of experience working in developing countries and deploying blockchains within these geographies. He stated that in his experience, the likelihood of fraudulent behaviours within a supply chain is linked to the economic state of the country which you are operating in. Meaning, in industries where a product is being sourced from a third world or developing country, the likelihood of fraudulent behaviours impacting the product and/ or the digital anchor, increases.

"We have to address the elephant in the room and that's corruption. The more you are dealing with countries that are less well developed, you're dealing with high volumes of product, and a lot of money, blockchain is absolutely necessary." – Interview Participant 10

Several interviewees also discussed challenges when trying to attain absolutely assured data. In this context, absolutely assured data is being 100% certain that the data is accurate and represents the digital twin of the product it is associated with. Absolutely assured data is something which Interview Participant 15 warns that deployment leads should consider if they need reasonable assurance or absolute assurance as the cost associated with going from near certain, to completely certain, is 'very expensive'.

"This is why it's very important to answer why you need an absolute assurance. If it is needed, then you will have see on alternative techniques because otherwise, you're looking at a very expensive blockchain solution." – Interview Participant 15

He continues by acknowledging that the challenges associated with absolutely assured data are industry specific. Likewise, the circumstantial data collection category contains codes relating to how the product, industry, or blockchain objective can inhibit the deployment of a blockchain solution or increase the complexity of the needed blockchain solution. Interviewee 12 explains how every industry, and each circumstance, has properties and conditions which are specific to that industry and as a result there is nuance between industries and circumstances which inhibit generalisability to a degree.

"Again, this is the question, each industry has its own uniqueness, right? Whether it's we're talking about food, there's some uniqueness. If we're talking about, we're talking to folks in precious stones, tracking of those, well that's a different ball game all together, right? You

look at any other manufacture and supply chain, everything has got their own nuances around each industry." – Interview Participant 12

Despite that, Interview Participant 08 notes how there are some events which can increase the similarity, and the challenges which are faced, by some industries. He discusses objects which can become 'off-grid' in the sense that they are no longer trackable on the blockchain. For example, if the objective of the blockchain is to aid in reverse logistics, then irrespective of industry there is a critical challenge in trying to get the product back so that it can be tracked on the blockchain. Alternatively, any industry which frequently features products as services, such as the automotive industry, can face similar challenges as the product needs to be reintegrated into the blockchain solution.

"For example, if I have this mouse and I just throw this mouse from there and it does not have any connectivity with its thing, it's become off-grid essentially. There is no way people can track this. For these kinds of problems, it becomes a very big challenge, yes. For circular economy, the use case, data collection is still a challenge… If the customer, for example, in the automotive industry does not go to a service centre or a company service centre, goes to, say, some third party or a roadside mechanic to get something fixed, there's no way that the company can even know anything about that product. So, a lot of these products, in fact, including electronic items, a lot of these products end up becoming off-grid. It's a very common phrase that we use." – Interview Participant 08

Alternatively, Interview Participant 15 states that "depending on the product, the complexity increases". Likewise, Participant 05 discusses instances where if a product requires third party certification in order to verify the product, then this can present challenges as the certification agency may not want to be involved with the blockchain project, and as a result, innovative methods which may compromise on the assuredness of the data may need to be used.

"In some instances, those third parties do not want anything to do with the project, and so you have to then get that inspection certificate or certification certificate directly from the supplier. And that's always challenging, right." – Interview Participant 05

Interviewee 06 also discusses specific examples where different products within the food industry have different requirements in terms of the data which is needed for the product as with cocoa beans you need to track moisture levels within the beans, whereas with meat you need to monitor the refrigeration temperature throughout transit.

"And we created in our model what we call food libraries that contain for about 25, yes short of 30, food categories. Data points are specific, I mean some are common of course when you talk about traceability. But data points that are related to a specific supply chain. You monitor moisture of cocoa beans." – Interview Participant 06

Lastly, the systems decisions category is a grouping of codes which pertain to strategic decisions concerning the type of blockchain being used and the specific platform being used. Within both of these categories, the most prominent codes concerned the decision-making process and evaluating between different types of blockchain and blockchain platforms to establish the most appropriate system for the use case. As was stated by Participant 09, deployment leads are faced with the dilemma of "public or private? And which public or [which] private?". Interestingly, there was a significant lack of consensus between some interviewees relating to the value that can be offered by public blockchain networks and private blockchain networks, as well as the value of specific blockchain platforms, which is reflected in the prominence of the 'indecision between public and private blockchain' and 'indecision and differences between blockchain platforms' codes. Notably, Interview Participant 02 cited deployment leads making the wrong decision between platforms as one of two reasons that a blockchain deployment can fail at the proof-of-concept phase.

"we see that there are projects that fail that particular point too. Usually for two reasons. One, they just simply can't figure out, they can't successfully bring their solution over to blockchain. Or they realise that maybe that a private permission blockchain is not the right choice and they look at other options" – Interview Participant 02

The remainder of this section will first discuss the challenges associated with public and private blockchains; before discussing challenges associated with specific blockchain platforms. However, these two categories are unavoidably interlinked as a quotation concerning indecision between platforms could reference issues associated with indecision between public and private platforms.

Interview Participant 16 held the strong belief that blockchain deployments in supply chains should use public permissioned protocols, supported by layer 2 and layer 3 blockchain modules, and cited the causal mechanism for failure in scaling blockchains throughout supply chains as being the decision to build private permissioned blockchain protocols instead of public permissioned protocols as "private blockchains cannot succeed" due to private blockchains offering no value over non-blockchain databases whilst also requiring their own infrastructure in order to run them which makes scaling more of a challenge. Further, Interviewee 13 stated that the strength of public blockchains going forward lies in their layer 2 solutions and network sharding. This is an unexpected finding given Clohessy & Acton (2019) found that private blockchains were developed in cases where resources were more abundant, whilst the SME's in their study were more likely to opt for public blockchains as a consequence of their limited resources. This could be evidence in a shift in attitudes towards public and private blockchain protocols or this may be explained by the variance of thought between the interviewees. However, it is worth noting that Interview Participant 16 has worked on several large budget blockchain projects, and as a result, this finding is directly contradicting the conclusions of Clohessy & Acton (2019).

"High-level, what we believe in, and I think it will ground the discussion, in terms of how we see blockchain's scale, private blockchains simply don't work, and we've been saying this from day one. Large Multinational Professional Services Organisation has never been on Hyperledger, L3 or any other private blockchain technology. The number-one reason is that...

Or two reasons. One, anything I do with that private blockchain, I can do with a simple database. And two, private blockchains that require their own infrastructure, unless you are China that has their own huge private blockchain, don't scale. And I think that by now, this was maybe a controversy five years ago, four years ago. By now, it's not anymore. At Large Multinational Professional Services Organisation, we are fully committed to the Ethereum ecosystem, and by that I mean, first and foremost, EVM [Ethereum Virtual Machine]." – Interview Participant 16

Interview Participant 02 also supported this view, stating that using public permissioned blockchains "reduces then the burden for parties to participate in the network because they don't necessarily have to have the infrastructure" which can make the systems easier to scale in circumstances where a supply chain member does not wish to host infrastructure. Participant 16 continued by explaining that the decision to use a private blockchain solution is like "having a discussion or a debate in 2005, what is better, to deploy a private intranet or use the internet infrastructure?". Thus, he believed that the value which can be offered by public permissioned blockchain projects is far greater than that of private permissioned blockchains. Interview Participant 13 also acknowledged the value of public blockchain solutions and he explained that, despite delivering several private blockchain solutions within his firm which he believed "are for a couple of reasons the best fit", there may be a need to switch these solutions to public permissioned networks as a consequence of the value which can be afforded by public permissioned solutions in a supply chain context. Similarly, Interview Participant 07 believed that there is a need for deployment leads to remain open to the prospect of switching to a new blockchain platform if that platform affords a greater level of value to the supply chain.

"I think it's very significant and in one year from now things will change so corporate would make more sense to move into using public blockchains with layer two solutions on top" – Interview Participant 13

Conversely, Interview participant 11B explained that as a result of her organisations work as a technology provider providing blockchain solutions to deployment leads, Ethereum – a public blockchain platform – was not a viable option for long term success of the project; however, she did not state why this is the case. However, this does recognise that there is indecision even between technology providers concerning the scalability of private and public networks, as well as the value which they can offer to a supply chain.

"But if we want to actually regularly conduct some kind of business that we can build a business on, it became very obvious very quickly that Ethereum was not going to be a viable option for that beyond a whole series of proof of concepts that we saw flourish and then burn out." – Interview Participant 11B

Alternatively, Interview Participant 02 held the position that each type of blockchain can offer value in different circumstances. Namely, he believed that a private permissioned blockchain project could be safer and less prone to security threats which could afford a better learning environment to develop blockchain competencies. Participant 05 who owns a private blockchain technology provider organisation believed that private systems offer a greater level of security than their private counterparts.

"Very rarely do people pry to the security of the ledger. Because, for the most part we work on private commissioned ledgers, not public ledgers like Blockchain or Ethereum. So, inherently, the security of the system is different." – Interview Participant 05

Several interviewees stated that one of the considerations when selecting a platform, and one of the challenges associated with some platforms, is that each platform has a different number of developers who are experts with that platform. Alternatively, Interviewee 11A stated that if an organisation decides to use an open-source platform, then keeping up with the latest updates is labour intensive and would be expected to increase maintenance costs as a result. This finding supports the research of Biswas & Gupta (2019) who found difficulty

associated with software updates as a causal barrier for blockchain adoption challenges. However, this research increases the specificity by acknowledging that this could result in a transition to another blockchain system, as well as or instead of, just maintaining the extant blockchain infrastructure.

"But the main market leaders, I would say, if we're going to talk about different protocols, well, they all have open-source versions and just keeping that up to date is such a massive job." – Interview Participant 11A

Several interviewees, such as Interviewee 01 and 07, also discussed specific blockchain platforms, and evaluated their pro's and con's, sometimes in relation to each other. This further evidenced the indecision between different blockchain platforms. However, a breakdown of specific platforms features is outside of the scope of this research and as a result is not provided.

5.1.4. Environmental Barriers

Environmental barriers is a grouping of codes referring to challenges which occur as a result of entities who are outside of the Deployment Lead, Supply Chain Members, and Advisors organisational boundaries. In this study, this included external stakeholders, policy makers and legal institutions, governing bodies, competing supply chains, and industries. As is evidenced in Table 15, 'regulatory and legislative challenges' and 'industry challenges', were the most frequently raised by the interviewees, whilst challenges associated with external stakeholder perception of blockchain and cryptocurrency also featured. The remainder of this section is structured to discuss these three categories.

Table 15: Environmental barrier codes alongside the number of files in which the code appeared and the number of times data was referenced with that code in total

Code ID	Environmental Barriers	Files	References
ENV09	Ease of blockchain deployment is industry dependent	5	19
ENV01	Different regulation in different localities	5	14
ENV02	Governing body agendas and-or standards challenges	5	10
ENV06	Blockchain suffers from its own hype	6	9
ENV10	Lack of external examples	5	8
ENV11	Different industries have different levels of understanding of blockchain technology	3	7
ENV03	Regulation disincentivising or prohibiting blockchain features or functions	3	6
ENV07	Crypto influences understanding of blockchain	5	5
ENV04	Different regulation in different sectors	3	4
ENV08	Crypto news can impact perceptions of enterprise blockchain	2	3
ENV13	Some countries don't want blockchain to reveal their corruption	1	3

Code ID	Environmental Barriers	Files	References
ENV12	3rd Party intermediary problems	1	2
ENV05	Lack of regulation incentivising blockchain	1	1
ENV14	External factors can inhibit an organisations ability to invest financial resources to blockchain	1	1

Several interviewees noted how operating a blockchain which is present in several jurisdictions with distinct laws can increase the complexity of the deployment. This is concordant with how legal and regulatory uncertainties were one of the most prominent barriers to blockchain adoption according to the surveyed experts in Biswas & Gupta's (2019) study where lack of universal regulation between jurisdictions was a sub-criteria of legal and regulatory uncertainties. Saberi et al. (2019) acknowledge this in their conceptual paper as they note how some countries have implemented strict regulation on some blockchain use cases which may increase complexity, especially if that trend or variability between countries continues. Whilst not being specific to issues arising when operating in several countries, Hastig & Sodhi (2020) found that regulatory uncertainty was one of the main barriers to adoption as this uncertainty increases the risk associated with investment into the technology. This finding may have implications for supply chain managers when in conjunction with the research of Reddick et al. (2019). The authors conducted research into blockchain technology within the public sector. In their study, they found that countries with a high degree of cyber-security are much more likely to have a blockchain project. This could show that existing attitudes toward security is a determinant of blockchain adoption. Thus, it would be expected that countries with varying levels of cybersecurity projects, will have different attitudes towards legislation; which will in turn create challenges for supply chain managers.

The increased complexity when operating in several jurisdictions may also be evidenced In the early research of Woodside et al. (2017), the authors tried to understand blockchain adoption using the Diffusion of Innovation theoretical framework. The authors found that there was a lack of certainty concerning blockchain legislation on a global scale, with many jurisdictions taking different approaches to regulate the technology. One caveat is that over 67% of the total number of 'regulatory and legislative challenges' codes within this research were cited in the five transcripts where the interview focused on one specific instance of blockchain being deployed throughout a supply chain. Thus, regulatory and legislative challenges were far less frequently discussed in the general interviews. Several interviewees discussed specific traits which when present in an industry, can inhibit the deployment and increase the complexity. Firstly, Interviewee 15 extended on this by detailing a trait which may increase the generalisability of findings between industries which feature this trait. The participant noted how blockchains become more complex when there is a physical good moving throughout the supply chain as there is an in-built latency between the physical goods movement and the financial and informational flows throughout the supply chain.

"In the case of a physical industry like supply chain where you have goods or products and services being exchanged, there is a disparity between the product flow, information flow, and the financial flow. Whereas for a music industry today, typically if you are creating content which is more in one medium, that is your online medium, you can really remove any latency between the physical flow of the music. Between let's say the recording labels or the artist and the consumer, the financial flow, and also the information flow of when was something listened to, and so on and so forth. So this is where that is different if you're on a same medium versus when you're talking about physical supply chains." – Interview Participant 15

Secondly, Interview Participant 17 noted how different industries have different levels of cooperation between competitors. In these industries where competitors working together is more common, he reasons that blockchain deployments throughout supply chains will become more complex as a result of the lack of desire to share certain data with

competitors, which could lead to a compromised blockchain solution being deployed which offers less value to its users as a result of the lack of desire to share data with competitors.

"When you move to the retail industry, for example, it's much more difficult to bring competing companies at one table to agree on something." – Interview Participant 17

Thirdly, Interview Participant 16 explained how blockchain is positioned to create different levels of value depending on the industry. He reasoned that each industry is subject to its own legislation and that this legislation can directly or indirectly incentivise the use of blockchain as a solution to the regulatory pressures. This was supported by Interview Participant 05 who also reasoned that the value the blockchain can offer is industry specific.

"Unless you have a very good motivation to do it, that is either regulatory or something like that, before you can exchange that value on the blockchain, it's a longer horizon, compared to financial services." – Interview Participant 16

Lastly, as was noted when reporting the technological challenges, industries where products undergo a physical transformation also increase the complexity of the deployment. Interview Participant 15 explained how this also applies to products that have (1) ingredients added to them; (2) they are manufactured; (3) if the product is packaged lots of times; or (4) if the product is distributed numerous times throughout the supply chain. Thus, he included the package of the product as part of the physical product as it is moved throughout the supply chain as well as the product itself.

"And another part is that the products don't move in the same unit. So it's not produced and consumed as one product. You might have a lot of ingredients going in, a lot of manufacturing happening, packaging, distribution, it being loaded onto a pallet. And then maybe at a location it's aggregated and disaggregated into product's pallet, which means

it's changing so many shapes and forms till it's consumed that it's very difficult to keep track of." – Interview Participant 15

Throughout the interviews, various participants spoke to how external stakeholders' perceptions of blockchain technology can impede the deployment of blockchain technology throughout a supply chain. One commonality was in interviewees recognising that these perceptions generally stem from a lack of understanding about blockchain technology which may occur for several reasons. Interview Participant 10 explained that blockchain was very hyped by the technology providers when the technology was in a state of infancy based on speculations of its prospective value that it may add in the future. He stated that this led to blockchain being recognised as what participant 15 described as being a 'magic pill' in the sense that it was believed that blockchain could solve any business problem. This finding is similar to the early hypotheses put forth by Francisco & Swanson (2018) which stated that social influence could inhibit or encourage blockchain adoption. This is also concordant with Biswas & Gupta (2019) who found market-based risks, which included hype concerning DLT adoption as a sub-criterion, was a significant barrier to DLT adoption. However, unlike their study, in this research it was of mid-level importance whilst in their study it was the third strongest causal barrier to blockchain adoption. Likewise, this finding shares similarities with one made by Queiroz & Fosso Wamba (2019). They found that in India, decision makers were susceptible to social influence from stakeholders which is likely to cause them to deploy a blockchain solution. However, they do differentiate between differing demographics of stakeholders. One caveat is that in their study, they find decision makers in the USA are not as susceptible to social influence as it is not supported that social pressures encourages the adoption of blockchain in the USA. This shows that external stakeholder perceptions of blockchain may impede deployment or encourage deployment, but that this is not generalisable in terms of geography. Similar findings were also made by Kamble et al. (2019). In their study looking into drivers of blockchain deployment, Kamble et al. (2019) found that a decision makers perceptions about what significant individuals to the decision maker want them to do regarding blockchain technology, positively impacts the decision makers perceived usefulness of blockchain, and that this in turn increases the likelihood of them actioning a blockchain project. Thus, when decision makers perceive the stakeholders

are in favour of blockchain, they are more likely to start blockchain projects. This study found that stakeholders could impede the blockchain deployment. Thus, together the two studies show that stakeholders can hold great influence over the blockchain project in a positive or a negative direction. Additionally, Hastig & Sodhi (2020) found that leadership of external stakeholders is a critical success factor which must be present in order for the deployment of a traceability blockchain project to be realised. Thus, this acknowledges the issues which may occur relating to external stakeholders.

"There was a lot of hype, a lot of marketing, a lot of overpromising. This is where I was brought into several conversations by governments and by industry associations to say, what the fuck are all these guys talking about? The blockchain can do x, y and z. It can even snowplough your driveway." – Interview Participant 10

Interviewee 14 also acknowledged this issue by stating that this issue of blockchain being discussed as a technology which solves any issue is a result of "a lot of people who over sells" the technology. Additionally, a portion of the interviewees cited cryptocurrency as being an underlying causal mechanism which can construe the perceptions of the stakeholders. Interviewee 04, 10, 12, and 14 also described how many people believe that blockchain technology in supply chains is the same as the blockchain use-case in cryptocurrency. All of these participants detail how cryptocurrencies can have a negative impact on blockchains in supply chains. Interviewee 14 describes how limitations placed on blockchains within the cryptocurrency use case are extended to apply to blockchains in a supply chain use case; despite these two systems operating in different ways at different scales, and as a result, having different limitations.

"Well, not so much because when you meet industry, whatever is the industry, when you begin to discuss about blockchains, they say, bitcoin, cryptocurrency, energy problem and so on." – Interview Participant 14

Similarly, he described how when cryptocurrency markets crash, this can increase people's scepticism of blockchain technology within the supply chain use case, despite being disparate applications. However, Interview Participant 12 did acknowledge that this misperception of blockchain technology as a 'magical pill', and the influence of occurrences within cryptocurrency use-case on the supply chain use-case, was more apparent in 2017 and 2018 and that it is reducing over time as blockchain technology becomes better understood within the mainstream. This finding is concurrent with the findings of Clohessy & Acton (2019) as blockchain association with cryptocurrencies was cited as being one of the four most prominent inhibitors of blockchain deployments in the cases studied. The previous statement by interviewee 10 concerning external stakeholder perceptions impeding deployment, and the statements about blockchain being influenced by cryptocurrency was concordant with the findings of Kouhizadeh et al. (2021). In their study, which used the TOE framework, they categorised perceptions of blockchain technology within their technological category. Their description of this code explained how it was concerned with the associations external stakeholders may make between blockchain technology and cryptocurrencies. The survey data showed that negative perceptions of blockchain technology was a prominent barrier, but that it was influenced by their immaturity of the technology factor. Thus, whilst they deemed it a significant issue, the authors stated that the root cause which must first be addressed is in the infancy of blockchain technology.

"Yes, it's interesting. In 2017, 18, when we used to talk with enterprises about blockchain, there was a little bit of, okay, explain to us blockchain, how is it different than bitcoin, crypto? People didn't quite understand that crypto is just one-use case of blockchain." – Interview Participant 12

5.2. Best practices for blockchain deployment throughout a supply chain

Consistent with the research questions within this study, the included best practices were identified in accordance with three criteria: (1) As a consequence of the Critical Realist philosophical position being applied throughout this research, the best practices are addressed towards the underlying causal mechanisms within the Real, that were highlighted in Section 5.1. as being inhibitors to blockchain deployment throughout a supply chain. This is because the phenomena within the real are the most significant to this research as these are deemed to be the underlying causes of issues, whilst observable problems within the empirical are considered to be outcomes of underlying mechanisms (Sayer, 1992); (2) they address challenges which were most prominent in the Template Analysis portion of the study, and (3) they are actionable in terms of the realistic plausibility that they can be implemented in industry. Criterion 3 is inherently subjective and as a result, there is a greater degree of researcher interpretation and influence with regards this criterion than in other areas of the study. However, contextual factors described by the interviewees were used as a lens to interpret the findings. Further, a range of short-form and long-form quotations are included throughout the section as a means of providing transparency to dataset and the interpretation of the dataset (King & Brooks, 2017). Consistent with the interviewees' experiences, Section 5.1. detailed the challenges which the participants had found that organisations face when attempting to deploy a blockchain throughout their supply chain. The challenges the participants found to be the greatest inhibitors were governance challenges and some organisational challenges. As a result, the remainder of this section focuses on governance challenges and specific organisational challenges.

Systems best practices were omitted from this research due to (1) these issues being better addressed by technical research as opposed to management research, and (2) from a

management research perspective, several of the interviewees expressed how technological challenges can always be solved by the dedication of human and financial resources as well as allotting more time for the project. Alternatively, the environmental challenges are factors which are out of the control of the deployment lead organisation and the supply chain members and as a result, are extremely difficult to influence. Thus, the remainder of this chapter focuses on actionable best practices which can alleviate the most prominent challenges discussed by the interviewees.

5.2.1. Governance best practices

The best practices in governance are divided into three subsections which form the framework for onboarding supply chain members into the governance. Each subsection represents a specific phase of the process of onboarding a supply chain member onto the blockchain ecosystem and were derived from the analysis of the interview transcripts. Thus, the first subsection details the overarching approach of the deployment lead which is being leveraged to bring supply chain members into the governance; the second subsection outlines the key points which should be negotiated between the deployment lead and the prospective member; finally, the last subsection presents the considerations post-negotiation once the supply chain member and deployment lead have agreed to cooperate to deploy the blockchain solution.

5.2.1.1. Governance best practices – Onboarding

Several interviewees discussed solutions to the initial onboarding challenge of onboarding through incentives and/ or power. As presented previously, some participants stated that there was a minimum level of influence which is needed in order for the onboarding through power strategy to be available. More specifically, Interview Participant 17 implied this minimum level of influence seemingly corresponded to buying power whereby the supplier sells a large quantity of their goods to the buying Deployment Lead organisation;

whilst Interview Participant 08 stated that a 'strong financial' position is what leads to the power asymmetry. Thus, further study would be needed in order to test theory from the organisational power literatures in the context of blockchain deployments. The need for uni-lateral organisational power imbalances between deployment lead and supply chain members is previously established in the literature. From their literature review, Duan et al. (2020) found that when the organisation trying to implement the system is an SME, they may find it harder to deploy the technology as they could struggle to convince the supply chain members to join the network.

Throughout the interviews, almost all participants discussed the necessity of providing value to the supply chain members in order to convince them to join the network. Interview Participant 6 explained that "You need to have a financial incentive or a risk mitigation" incentive in order to persuade supply chain members to join the network. Moreover, seven different means of providing incentives for supply chain members to be onboarded to the network were detailed by various interview participants which can each be categorised as a financial incentive or a risk mitigation incentive.

Within the financial incentives, the most frequently discussed was that the value of joining the network could allow for suppliers to provide banks with attestable evidence which could be used by the supplier to get a loan.

"One of the goals of the network I would say was to be able to provide attestation that this farmer would be able to, on a traditional flip-phone, be able to actually have an attestation to a bank and say, look, I sell to Starbucks so can I get a loan, which would then allow them to produce more coffee sustainably." – Interview Participant 02

One participant extended upon this by noting how in some circumstances they may be able to get loans at more favourable rates when using a blockchain to provide evidence of their supply chain.

"is to provide better conditions or better pay-outs to farmers. So, when the farmer sees okay, there is minimising the risk of my crop loss. Or there is increasing the financial benefits that I have because the financial institution now is providing me a loan at a lower rate and it's a faster process. Then it's easy to work with them because you work towards their benefit." – Interview Participant 06

Another financial incentive which was discussed was the possibility of improvising the price which the Deployment Lead would procure goods for from the supplier. Notably, this statement was made in the context of beef supply chains where fraudulent beef is common; thus, this incentive approach may be more possible in instances where the existing value of the good is hindered by the possibility of the good being fraudulent.

"The pitch was, if I can improve the gate price of your cow, and I can do that, would you be interested?" – Interview Participant 04

Another financial incentive which was discussed was in providing an improved number of days accounts receivable for the supplier so that the supplier receives payment for their goods earlier, improving their cash to cash cycle, and reducing the duration which the supplier has to fund their own operations.

"If by some means I can say that quality inspections are going to be all done through a smart contract and ILT-based systems, and what that means is our procure-to-pay cycle is going to significantly reduce, so instead of you getting your money, instead of a supplier getting the money in 30 days, he will get it in 20 days, a supplier would be absolutely happy to be onboarded on a network like this." – Interview Participant 08

One financial incentive which could be used as an incentive is whereby the blockchain solves a significant business issue for the supplier which can have financial ramifications. Interview

Participant 02 was discussing a case where royalties were automated on a blockchain in order to establish and pay publishers on their blockchain network. In this case, he noted how because of the complexity involved in the royalty program, there are large disputes which consume a lot of financial and non-financial resources to resolve for all parties. In this case, he stated that having a central point of truth which had automated versions of the real-life contracts, meant that the publishers were encouraged to join the network as it would reduce the financial burden of dispute resolution. Further, them having access to this central database of truth allowed them to perform audits to ensure that the smart contracts are executed correctly; was in itself a motivation to join the network even in cases where they did not have a need to perform audits on the data.

"If they needed to go and actually do a formal audit, the data is there to be able to do that and it's traceable and trackable. Whether they actually do an audit or not, that remains to be seen, but the promise that it could be done was sufficient enough." – Interview Participant 02

Lastly, two participants also discussed the value which can be offered to the supply chain member by publicising their product through the blockchain. This approach seems appropriate in instances where the end consumer have the ability to scan a barcode which will then display the supply chain and life cycle of that specific product. This can improve awareness of the supply chain member and may indirectly have a financial benefit for them.

"sometimes you articulate the value for each. Hey, farm, if you're growing these amazing tomatoes, if we put your name in the chain, and maybe there's interest and publicity for you." – Interview Participant 12

"I just want to mention the further you go back in the supply chain, like, to the growers, the question is what incentivises the grower to be part of such an initiative. And for a farmer or grower, for them it's to make sure that they are trustworthy in terms of delivering high-

quality product. Because usually they got lost during the supply chain because in the end you just see the brand name but you don't see who actually grows the specific product. If they can market themselves on such a product, this also helps them to be trustworthy and gain value." – Interview Participant 17

Several interviewees also detailed how non-financial incentives can be used which still encourage supply chain members to join the network. As was reasoned by Interview Participant 08, the non-financial incentives are largely about risk mitigation for the supplier. One way in which this is discussed was provided by Interview Participant 12. He stated that if the blockchain is capable of providing real time data that can be accessed by the supply chain member, then this can be used by the supply chain member in order to more effectively respond to incidents. This incentive seems more valuable in circumstances where the goods are safety critical whereby they can have a harmful impact on human life.

"Or sometimes some data may be interesting for the farms to get in real time. Let's say there is a farm, there is five miles down the road there is livestock or some industrial where water's seeping underground. If the quality of water changes, they get to know very quickly then when it happens, rather than after a while, right? So, you can prevent a lot of problems if you get data on time." – Interview Participant 12

The final incentive relates to interorganisational trust and as such, may be preferred in instances where trust is lacking between Deployment Lead and Supply Chain Members. Interview Participant 05 discussed how open-book accounting can be used as a technique which can be used to mitigate some of the fears of the supply chain member in order to convince them to share data and join the network. In this sense, the Deployment Lead organisation would also share data with the Supply Chain member, as opposed to the more common unilateral data exchange where the Supply Chain member shares data with the Deployment Lead. In doing this, the interviewee explains how reciprocating the sharing of data can ease the Supply Chain Members concerns and could convince them that their data

and products are being used in a trustworthy way that will not result in them being taken advantage of.

"In the most part, if you make it a symbiotic sharing of information, meaning that the producer would like to know, where is my product, my ingredient ending up? What products are you putting what I grow into what, right? Is it going into a soda? Is it going into a candy bar? Because they don't always know. So, if you can find that, there's definitely harmony where they get data back which they're craving for." – Interview Participant 05

Derived from the interview data, Table 16 summarises the above findings by detailing the three proposed onboarding strategies – (1) Onboarding through power, (2) onboarding through risk incentives, and (3) onboarding through financial incentives – alongside some specific methods which may be used and some contexts when the proposed method may be appropriate.

Table 16: Types of onboarding strategies alongside some contexts when they may be appropriate

Onboarding Strategy	Onboarding Method/ Incentive	Appropriate When
Power	Power Asymmetry	Weaker financial position of supplier
		Supplier dependence on buyer is high
Risk Incentive	Real time data assistance	Safety Critical
	Bilateral open-book data disclosure	Supply chain member lacking trust in Deployment Lead
Financial Incentive	Loans at more favourable rates	Supply chain member struggles to procure product
	Price Increase	Fraudulent goods diminish the historical price

	Improved accounts receivable	Poor cash-to-cash cycle
	Reduced costs for the supply chain member	Blockchain solves their business issue
	Increased publicity for the supply chain member	Consumer interaction with blockchain

5.2.1.2. Governance Best Practices – Negotiation

Throughout the interviews, some of the participants described some best practices which occur at the negotiation phase of onboarding supply chain members to the network. As was detailed in Section 5.1.1., the challenges which need to be resolved pertain to rules of engagements and permissions, funding sources, and infrastructure. Of these topics, rules of engagements and permissions were regarded as the most prominent challenges which needed to be negotiated between the deployment lead and the supply chain member. Several interviewees discussed key points which need to be considered at the negotiation phase of onboarding in order to have a successful deployment. Firstly, Interview Participant 02 differentiated between the two different types of organisation which may be negotiating to join the network. He explained that some organisations will join in an 'administrator' role, whilst others will join in a 'member' role. He continues by explaining that members and administrators will have different rights, tasks, and permissions on the network.

"There is effectively an administrator role and there's a member role. An administrator can add other members to join, can remove members, change permissions. A member is just able to participate." – Interview Participant 02

Likewise, Interview Participant 10 expressed how a key discussion point is in deciding which data should be stored on the blockchain, and which data should be stored off of the blockchain. This is an extension of the research of Wang et al. (2019) who found that their

interviewees felt that convincing supply chain members to share their data would be a major hurdle facing blockchain deployment. Further, the interviewee continues by stressing that there should also be a communication plan which explains how the prospective participant should engage with the other organisations.

"They've never thought about, oh shit, we have a regulatory requirement to keep data from two years or whatever it is within that country, so we keep that data, but how do we segment out master data that's public and master data that's private? How do we communicate with our trading partners? We could have production partners, where we're not manufacturing ourselves but we share the recipe and the specification to our supplier and they actually make it." – Interview Participant 10

Interview Participant 16 expanded upon the data storage points made by Interview Participant 10 by stating that "the data you put on the blockchain is minimal, not maximal", Thus, this participant believed that it is a best practice to store the original cached master data off chain, and to instead use the blockchain functionality to tokenise and hash the off-chain data on the blockchain in order to realise the benefits of blockchain without compromising on the security of private information.

You don't put any information you don't need on them. So, when we say use public blockchains, we don't mean put all your organisational data on a public blockchain. We mean tokenise the data, hash the data, so notarise it on a public blockchain, use the tokens in order to exchange value, keep the private information on regular databases… And keep it in off-chain databases and real by using hashes on a public blockchain. So, there are ways to, in that sense, eat the cake and keep it whole, and still use the public internet infrastructure. So maybe that's a really important point. – Interview Participant 16

Similarly, one interviewee extended on these points by also including details about how the supply chain member will interact with the blockchain itself, and to understand their

responsibilities and role within the network. This included negotiations around behaviours which can elicit automated sanctions to be activated on the blockchain demonstrating that there is a need for all supply chain members and deployment leads to have a thorough understanding of the financial agreements. These findings share significant similarities with the early conceptual work of Beck et al. (2018). In their study, they developed a research agenda for blockchain governance. They reasoned that decision rights, are one of the three dimensions of blockchain governance and that it is necessary for future research to understand how decision making, and rights and responsibilities are going to be established on the blockchain system. This research provides empirical evidence which supports some of the issues the authors proposed, whilst increasing the specificity by applying it in a supply chain context.

"Governance model is probably the first thing that you should start with. What do you do as a supplier in this network? Where does your liability end? What do I do as an OEM in this network? Where does my liability end? When are those financial transactions that we are talking about going to be executed? So, for example, if I want to write a smart contract where, say, the food is being transported, if the temperature exceeds to a degree three times in the process, I'm going to charge a damage fee to the logistics person." – Interview Participant 08

Lastly, Interview Participant 02 noted that infrastructure also needs to be discussed with the supply chain member. Specifically, an agreement needs to be reached concerning whether the deployment will be a multi-node deployment or a single-node deployment.

"Do you have five people who want to come together to create a network, a completely decentralised network on day one? If yes, then let's go ahead and create a decentralised network. If not, let's have a single node deployment." – Interview Participant 02

To summarise, Table 17 is derived from the analysis of the interview transcripts and outlines the various points which need to be negotiated between the supply chain members and the deployment leads. The table accounts for the potential differences in role of the supply chain member by including points specific to administrators as well as members. The table is expected to function as an aid when a Deployment Lead and a Supply Chain Member are negotiating the Supply Chain Members prospective onboarding to the blockchain network.

Table 17: Topics which interviewees recommend discussing with prospective blockchain network members in relation to their role within the project.

Role	**Topics**	**Points to Negotiate**
Members and Administrators	Behaviours	How will they interact with the blockchain?
		What will the organisation be required to do on the blockchain?
		How will the organisation communicate with the other organisations?
	Sanctions	What behaviours can elicit sanctions on the blockchain?
		What are the organisations liabilities within the network?
	Provide data	What data will be collected from the member?
		What data will be stored on the blockchain and what will be stored off the blockchain?

	Viewing data	Who will be able to view their on-chain and off-chain data?
		What data will they be able to view?
	Funding	Who is funding the upfront costs for the deployment?
		Who is funding the maintenance costs post deployment?
	Infrastructure	Will the deployment be multi-node or single-node?
		Will the participant organisation host their own nodes in the network?
Administrators	Add/ remove members	Who will the administrator be able to add to/ remove from the network?
		How will the administrator add/ remove members to and from the network?
	Editing permissions	Whose permission can the administrator edit?
		How will the administrator edit permissions?

Consistent with the issues raised by the interviewees and some of the best practices identified by the interviewees, the table includes eight topics each with various points which need to be negotiated prior to the deployment. These include (1) the ability to add/ remove members, (2) the ability to edit permissions to access data on the blockchain, (3) the

expected behaviours and how they will interact with the blockchain, (4) to agree to sanctions which occur as a result of undesired behaviours, (5) to agree on what data the Supply Chain Member will be asked to provide to the blockchain, (6) to agree on who will be able to view the Supply Chain Members data, (7) to establish how the onboarding will be funded, and (8) to come to an agreement on how the blockchain infrastructure will be deployed.

5.2.1.3. Governance best practices – Deployment

Throughout the interviews, many of the participants discussed the need for a roadmap to be established with the objective of using this to aid in the onboarding process. In this context, the roadmap refers to the plan for the blockchain solution and the network of users. Thus, in anchored governance setups, the deployment lead would be responsible for the roadmap whilst in consortium governance structures the consortium would be responsible for the establishing the roadmap. The roadmaps described by the participants detailed how the onboarding of supply chain members would be managed. Each participant provided a slightly different perspective on the specifics of the roadmap. Interview Participant 07 noted that this point of establishing the roadmap signified the start of the collaboration between all of the members. One commonality between interviewees was the idea that the roadmap should be established early in the project. For example, Interview Participant 14 explained how developing a roadmap early on is a necessity as even if the roadmap is imprecise or inaccurate, you can always adapt it as you go on. He continued by explaining that as you attain new information through speaking to the supply chain members, you should then adapt the roadmap to be accommodating of that new information.

"We do a study and after we begin to discuss with the people involved in the ecosystem and you have 50% of the people who say, I will not play this game for different reasons. So, you have to change your topics, within the same area but you have to change your idea, put [unclear] and look if your business plan can be this time sustainable." – Interview Participant 14

Most notably, the largest consensus between interviewees when discussing roadmaps pertained to critical stakeholder involvement. Several interviewees stated that the project roadmap needs to include a list of critical stakeholders to the project whose involvement in the project is necessary in order for the system to add the desired value. Interview Participant 02 explains how a small subset of critical supply chain members are usually identified and then involved at the start of the project; then the less critical partners are onboarded later. Thus, he suggests that there is a need to establish a hierarchical list of supply chain members regarding their criticality to the project and that those deemed most central should be involved early on in the project.

"And this tends to be where a lot of the challenges that I've seen come in with consortiums has been in terms of scaling the consortium, is getting agreement. It's easier to get agreement with a small subset, three or four, that are willing to pave the trail in an enterprise blockchain consortium, to agree. And I say easy. That still can take months. It's the scaling out to the potentially dozens, if not hundreds, of other parties to join the consortium [that is where projects fail]". – Interview Participant 02

Several interviewees note how some additional factors inform who are deemed critical to the deployment. For example, interview participant 15 states how it is often easier to onboard organisations early whom the deployment lead has a good relationship with. These findings share significant similarities with the early conceptual work of Beck et al. (2018). In their study, they developed a research agenda for blockchain governance. They reasoned that decision rights, are one of the three dimensions of blockchain governance and that it is necessary for future research to understand how decision making, and rights and responsibilities are going to be established on the blockchain system. This research provides empirical evidence which supports some of the issues the authors proposed, whilst increasing the specificity by applying it in a supply chain context. Similarly, Interview Participant 02 recommends taking 'the path of least resistance' in terms of collaborating with supply chain members that want to be involved early on in the project.

"Now depending upon the intent and scale of the consortium, those number of critical partners could be a small number, or it could be a large number. So, they'll prioritise and typically go with the path of least resistance in terms of the ones that are willing to agree to get the thing off of the ground and get the pilot, all right." – Interview Participant 02

Two additional considerations were also proposed by two of the interviewees in relation to governance best practices. Firstly, Interview Participant 02 recommended having a neutral 3rd party being hired to enact as an arbiter which would oversee and enforce the agreed upon governance throughout the network. This can alleviate some trust issues and ensure that no single organisation is manipulating the other members or acting dishonestly. However, Interview Participant 02 acknowledged that the majority of the projects which he had worked on, used the anchor governance structure and as a result, having an auditing firm run the governance may be more applicable in anchored governance circumstances due to the power imbalances in relation to the blockchain between the deployment lead and the supply chain members.

"Typically, the one that has started the project, that tends to lead those efforts. The intent is always that there will be a fairly long pilot phase. And then going into production, is a slow scaling method where their intent is to really ideally decentralised from not being an anchor member perspective. Maybe a third party, non-biased entity. An auditing firm or somebody that runs that consortium per the governance rules and runs a governance board etc." – Interview Participant 02

Additionally, Interview Participant 07 recommended establishing a separate legal entity which has representatives from each of the collaborating organisations who are initiating the deployment. It is worth considering, this recommendation was made in the context of consortium governance structures, and not anchor governance structures. As a result, its applicability may be limited only to consortium governance structures.

"So, thinking back, we were very close to creating and getting funding for creating a legal entity. We should have started that from the beginning." – Interview Participant 07

Lastly, several interviewees discussed the importance of having a shared vision for the project and having a common goal between all of the involved organisations. This is especially relevant given the prominence of the 'Lack of collaborative business models' and 'Competing stakeholder interests and objectives' codes within the template analysis. As noted by Interview Participant 17, there is a necessity for the collaborative business models to be guided around achieving a common goal that is agreed upon by the member organisations. Similarly, Interview Participant 07 notes how in his experience, too little attention was paid into establishing and communicating a common goal between the collaborating organisations and as a result, this created friction and issues between the supply chain members.

"I think there has been too little attention to what is the shared vision, what we want to achieve in the short run to make really progress but also the controls, what are your thoughts and what are your responsibilities, and that you could actually come back to that. You can always change and adjust them but you should start at least with an initial one and I think that was not outspoken clearly, especially with expectations." – Interview Participant 07

5.2.2. Organisational best practices

The most frequently cited organisational barrier codes were 'necessity for blockchain ROI to add value' and 'lack of blockchain expertise' with 16 and 15 of the interviewees mentioning them respectively. Thus, they were the most generalisable issues irrespective of differences in the experiences and industries of the participants. Further, they were also the most cited

challenges between the interview transcripts, showing that the participants felt a need to discuss these challenges at a greater depth. This is significant given the open-ended phrasing of the interview questions affording the freedom of choice in topics to discuss for the participants. As a result, several interviewees described best practices which can be actioned to mitigate these challenges in a greater level of detail than other organisational barriers. Thus, Section 5.2.2.1 focuses on addressing issues pertaining to return on investment whilst Section 5.2.2.2. discusses best practices to mitigate lack of understanding about blockchain technology.

5.2.2.1. Organisational best practices – Return on Investment

Throughout the interviews, many participants stressed the significance of how the lack of value which the blockchain could offer to an instance, within a given budget period, could be an inhibitor to the successful deployment of the blockchain throughout the supply chain. As a result, many interviewees were keen to highlight approaches which could be undertaken in order to mitigate the impact of these issues. Firstly, several interviewees noted that the initial approach should be to see if the business problem can be solved without a blockchain solution, potentially removing the need for a blockchain project. This finding supports the conceptual work of Angelis & Da Silva (2019). The authors developed a framework to aid management in assessing their need for a blockchain project. They stated that organisations should attempt to solve the issue without a blockchain, as often systemic changes in business operations may be a more effective means of addressing the business need at a lower cost. This finding is also concordant with a finding made by Wang et al. (2019) who found that several of their interviewees recognised that there is a need to attempt to solve business issues using traditional databases as opposed to the use of a blockchain.

"And I also say that I'm very much a sceptic, so let's see if we can solve everything that you need for your business needs without talking about or using blockchain. And potentially at

the very end can we plug that in to just evolve a little bit of the… Or let's say solve some of the inefficiency" – Interview Participant 11b

Once the business need has been established and a blockchain solution has been identified as the appropriate tool to address that issue, interview participants 06 and 10 stated that key performance indicators should be established which can then serve as an evaluation criteria against which the value that the blockchain project can offer can be assessed against. This can then serve as targets for the project as well as being a means of defending the project in order to secure subsequent funding. These KPIs will be specific to each instance and should ideally be negotiated prior to a pilot as they can aid in discussions with potential supply chain members when seeking to onboard them into the governance.

"This needs to be often hard KPIs, with numbers, with what you want to achieve. A reduction of 30% of the interest rate of the loan. I'm just giving examples. But you need to provide KPI otherwise there's this sentiment of say, okay yes. Even on time and cost it saves. You need to provide a value."- Interview Participant 06

"Most of the time companies will say how will this help me increase revenue? There are normally three things that companies ask. How will it help me increase revenue? How will it help me to reduce costs? The third is, how will it help me optimise assets? The fourth variable in there could be something like, how will it help me increase customer satisfaction? That metric can change but the other three metrics are standard in 99.9% of projects." – Interview Participant 10

The interview participants also discussed some examples where blockchain has an inherent value which can make establishing the value which blockchain offers a lot easier. Across the interview transcripts, several conditions were discussed which, when present, may elevate the value which a blockchain solution can afford to the deployment leads and the supply chain. Thus, when these causal mechanisms are present, blockchain deployment should be

more straightforward in terms of establishing and realising a satisfactory ROI. The most frequently discussed condition, perhaps as a result of the participants weighting toward the food stuffs industry, was safety-critical supply chains. In this context, a safety-critical supply chain is a supply chain which provides a product or service which can cause harm or fatalities to end consumers when something goes wrong. Several interviewees gave examples of spoiled foods which needed immediate and accurate recall in order to identify which batches of produce needed to be recalled and which were safe for consumption. In these instances, the real-time traceability which blockchain can enable when used in conjunction with supporting technologies can minimise potential losses as fewer goods need to be recalled whilst allowing for increased determinism in how to manage the recall of the unsafe goods and any potential health risks.

"For Large Multinational Retail Organisation this was mainly an internal benefit having this oversight of traceability, since when you've got issues with your food, you need to make sure you can remove this food as quickly as possible from your shelf. But to pinpoint where the issue is coming from, it can be at the warehouse, it can be at the production location or at the farm. If you can do that within seconds, you also know exactly what food you need to remove, like which batch, which box. The time you don't know, you cannot trace the food, let's say a week, this is the time you would need to be on the safe side so you just throw away all the food. So, it's a huge food waste, but also because you throw away a lot of good food or non-risky food in this sense." – Interview Participant 17

"And then tying into that in addition, say trucking company two does that two or three times over a period of time, they may then be banned from the network. They may be banned from the process, incur penalties, etc. So, the promise of not only automating that but at the end of the day keeping end consumers like you and I from getting sick from drinking spoiled milk or yoghurt adds super-high value." – Interview Participant 02

Another condition which may increase the value which blockchain can offer is in instances where the supply chain contains unbanked supply chain members. The digitalisation of the

supply chain and the deployment of a blockchain solution supported by additional technologies can improve the reliability of the supply chain. Interview Participant 09 states how in these circumstances, previously unbanked members will have an easier time securing business loans; meanwhile Interview Participant 02 observed that this can aid in the procurement of goods for their organisations.

"If you've got hereditary land ownership and you don't have a robust system of records in your country. So, if you don't have a title, how do you prove own the land? How do you prove you own the land if you want to insure your crop? Oh, you can't. How do you prove you own the land if you want to use it as collateral for a loan? Oh, you can't." – Interview Participant 09

Few interviewees also affirmed that where there is a lack of trust, that blockchain may be a large value add. For example, Interview Participant 10 cited an example of a project he is actively working on where he recommended a blockchain solution in order to verify the credentials of any collaborating party. This finding may be supported by an unexpected result in the research by Queiroz & Fosso Wamba (2019) which was looking into the influences of blockchain deployment as opposed to barriers. The authors hypothesised that in instances where interorganisational trust is high, it is likely that organisations have actioned plans to deploy a blockchain solution. However, their study found that this is not supported in either India or the USA.

"Also, part of their projects when they're looking at deploying. One of the companies that I'm advising on a weekly basis for the last three years is in trade finance, so moving large commodities of goods around the world. The reason why I brought a blockchain into their technology platform was because of the lack of trust in that area and to be able to verify credentials of the trading partners." – Interview Participant 10

Similarly, Interview Participant 16 stated that in industries where the threat of fraudulent behaviours are high, then a blockchain solution supported by additional technologies may be a means of adding credibility to the supply chain. This finding is discordant with a study in an adjacent research field which was conducted in the public sector on a sample which included some supply chain use cases. Reddick et al., (2019) found that governments operating in countries with high levels of corruption were not more likely to adopt blockchain solutions. However, it is worth noting that this research was pitched at public sector level as opposed to private enterprise. This finding also provides empirical evidence supporting the early conceptual work of Wang et al. (2016). The scholars proposed a framework for managers to use to evaluate blockchain adoption suitability. In their framework, they predict that blockchain may be a suitable technology for organisations who need to trust the data which is being stored. Likewise, the conceptual research of Chen et al. (2018) reasoned that blockchain may be suitable due to its potential to add value, in use cases where the data needs to be assured and trusted.

"So, you need to have a very good reason, meaning if I am a luxury brand and I'm suffering from forgery and powerless trading, fraudulent [?] import, that would be a big motivation." – Interview Participant 16

He also continued by stating that in any industry with strict regulatory compliance or where there is a need for ECG reporting, that a blockchain solution may be the most appropriate value-add tool available. Likewise, Interview Participant 10 stated that in any circumstance where the threat of litigation is high, then a blockchain centric solution may be the most appropriate tool to mitigate these risks and in turn create a substantial value for the supply chain.

"By putting a blockchain in place, they have eliminated 99.7% of the errors that they were having previously. Those errors could be costly. They could lead to litigation. So blockchain was very suitable for solving that issue with invoicing between the parties." – Interview Participant 10

Derived from the interview data, Table 18 summarises the aforementioned findings by showing some circumstances where a blockchain solution may be an inherent value add to a supply chain. However, one significant caveat is that there is still a need to assess each circumstance by (1) evaluating if the business need can be solved without a blockchain and (2) devising a series of KPIs which the value-add of the blockchain project can be judged against. One commonality between all of the discussed these conditions is that they are all alleviated by one or more features of blockchain technology; such as traceability, real time data assistance, immutability etc.

Table 18: Table showing some supply chain conditions which blockchain may be well positioned to add value

Conditions where blockchain may add value
safety critical supply chains
unbanked supply chains
lack of trust
industries where litigation threat is high
industries where fraud is prevalent
regulatory compliance
ECG reporting
Paper based processes

5.2.2.2. Organisational Best Practices – Lack of Understanding

One of the most apparent inhibitors of blockchain deployments throughout supply chains was a lack of understanding of blockchain competencies at the deployment lead organisation. In order to address this issue, three non-exclusive main approaches were identified which each can be used on their own or alongside the other strategies in order to realise the successful deployment of the solution. Firstly, Interview Participant 02 states that limited scale private permissioned blockchain projects can be used as a means of developing the core blockchain competencies necessary for subsequent larger scale blockchain projects. The advantage of this approach is that the blockchain projects can be trialled in an environment where the relative risk is low whilst still upskilling the workforce with the view to tackling larger scale projects in the future.

"But my belief is that project allowed them to gain enough expertise and familiarity with blockchain technology that allowed them to then go to the Odyssey platform that they're launching now. That's where I see a lot of these customers in. Again, their private permission enterprise blockchain consortiums allow them a very safe way to learn about the technology and build a system without any exposure to a public mainnet." – Interview Participant 02

Secondly, the deployment lead organisation can outsource the project to a technology provider who already has the required knowledge and expertise to deliver the blockchain solution at the required specification. Interview Participant 10 notes how this can be difficult as there is a need to identify 'enterprise architects' who can (1) build the blockchain solution, (2) integrate the supporting technologies, (3) integrate the blockchain system with the legacy systems and wider technology stack, (4) ensure the blockchain is interoperable

with other blockchain solutions, and (5) consult on how to integrate the blockchain solution with the business architecture.

"You need enterprise architects who can build a hotel. You don't need someone to go in and say I can build a lobby for you. You need those people that have that high-level vision of how everything operates together. The enterprise architects are the ones that look at integration. They look at interoperability. They look at the business architecture, then the technical architecture, how to roll it out, how to maintain it. And how to make sure that there are no vulnerabilities in there and how to make sure that the system functions as a system without being locked and loaded" – Interview Participant 10

Lastly, Interview Participant 02 explained that some organisations opt to build an in-house "blockchain centre of excellence". This involves developing a team in-house whom focus on research and development in order to build the technological competencies required for future blockchain projects. However, this is a resource intensive approach and as a result is not a strategy which will be available to all organisations.

"There are two models that I've seen. There are companies that will invest and build a blockchain centre of excellence, a team that's just designated and focused on that and just let them go and do R&D and even build projects to build the expertise in-house. Very few companies do that. A good example is Multinational Oil and Gas Organisation. Multinational Oil and Gas Organisation does a very great job of this. They've got a very strong blockchain centre of excellence, very sharp people on that team. There are other companies that do that as well, but the majority of them really have to, at this phase, rely on partners. They can either try to bootstrap a team and build, if they have the headcount and resources to do that, or they bring in a trusted partner that has experience in this space that is there not only to help build the solution but also really to train them on the technologies that go into the process." – Interview Participant 02

Building a blockchain centre of excellence is a model also advocated for by Interview Participant 6 who stated that if he was in the position of power at a large multinational he would champion his internal IT department to build out the blockchain solution and to integrate it into their business systems. However, like Interview Participant 02, he does acknowledge that this strategy is more appropriate at organisations with large resources as this process may be more resource intensive. Additionally, he reasons that an undertaking like this should be done in conjunction with the help from an outside partner who already has the required technical expertise to build the system. Thus, a combination of the aforementioned strategies may be used to elicit the desired results and this should be evaluated on a case by case basis.

"I mean if I were a C-suite level executive in a food company or in a big company there, I would empower my own IT team to say, okay, you are owning this. You are the ones that are bringing us to the new digital era. Select the partner that you want to work with. Explore the different technologies." – Interview Participant 06

5.3. Findings from the case interviews

As described in Section 4.1., this Critical Realist research applied an abductive and retroductive inferencing approach. As a result, this research sought to employ several approaches, based on the work of Danermark, et al., (2005), which can be used in Critical Realist research to understand the conditions which are needed for an event to occur when using retroductive and abductive inferencing. In this interview study, this was achieved through a series of interviews which collected data generally to explore patterns between different contexts, and to identify key themes that occur in relation to the three research questions. This was simultaneously further explored in specific instances through collecting data from interviewees which pertained to a specific case where a blockchain project had been initiated. This involved the collection of evidence from typical cases, atypical cases, and engaging in cross-case analysis. In this study, a subjective definition of typical was

applied where a typical case had to meet four criteria: (1) the blockchain and the supply chain must be present in several countries; (2) the supply chain must include a product where the ownership of said product is moving downstream within the supply chain; (3) the blockchain has a single objective, such as track and trace; and (4) the blockchain was either at Proof-of-Concept or Pilot grade, as most blockchains were not production grade deployments at the time of evidence collection. Atypical cases were also identified. Atypical cases were defined as cases where one or more of the above criteria were not present. This study collected evidence from five cases. Case 01 was a typical case which tracked the movement of beef throughout a supply chain from farmer to consumer. Case 02 was also a typical case at the time of evidence collection as it sought to track goods coming into and out of a port. However, In the future it was intended that additional functionality would be added to the blockchain which would have made the case atypical. Alternatively, Case 03, Case 04, and Case 05 were atypical to varying degrees. Case 03 bears several similarities to the two typical cases; however, in Case 03, the blockchain performed multiple functions instead of just being a track and trace system and the blockchain was a production grade system. The comparisons between Case 03 and Cases 01 and 02, could reveal insight into how adding additional functionality could impact the deployment of the blockchain system, as well as showing how the challenges and solutions that can occur during the transition to production grade systems. Case 04 is atypical because the products which are moving through the supply chain are residential properties and as a result, do not follow the conventional processes of consumer goods where they travel from producer to consumer. Further, this blockchain is in production, however, additional functions are actively being tested as Proof-of-Concept projects at the time of evidence collection. This extreme case can reveal insight into the challenges of legislative bureaucracy when deploying blockchain systems. Lastly, Case 05 is atypical because the ownership of the goods is not changing as it involves the leasing of goods and infrastructure. This conforms with the wider definition of supply chains being applied in this study which is based on the work of Mentzer et al., (2001), that was presented in Section 4.2.1., and is designed to account for the popularity of loaning goods as opposed to purchasing them. Analysis between Case 05 and the other cases could reveal insight into how the challenges of deploying blockchains alter when not having to deal with ownership changes, but whilst having to deal with leasing. The following presents an overview of each case. This includes contextual information such as the type of

blockchain, and when the case started. This is accompanied by an outline of the interviewee and their role in relation to the project. Lastly, the findings from each case study are presented in relation to the research questions detailing the key themes from the case study alongside corresponding evidence from the interview transcripts.

Each case is documented below. Each case is differentiated into three subsections. The first provides an overview of the case being studied. This includes information pertaining to the context of the case. This comprises information about the involved organisations, the objective for the project, the scope of the blockchain and its functionality, amongst other information to provide a thick description of the context. This second subsection then outlines information about the interviewee. This includes information concerning the interviewees role within the project, their responsibilities, and their experience. The objective of this section is to provide a transparent account of the interviewee so that any reader may draw their own interpretations of the events by acknowledging the source which the information is coming from. The final subsection explores the specifics of the case pertaining to the research questions – (1) identifying barriers to blockchain deployment and the causal mechanisms which activate them and (2) identifying best practices which can be implemented to address some of the aforementioned barriers. As not each case found the same themes to be present, this section is structured according to the project phases for the blockchain deployment. This increases the specificity of the thematic analysis by facilitating a greater contextual understanding of when and how challenges may occur, and at what stage of the deployment different best practices may be implemented to account for the challenges. Thus, barriers and best practices are included simultaneously, being structured according to the progression of the blockchain project. This structure was preferred over organising the subsections by research question as a consequence of how some of the interviewees were unable to commit sufficient time to explore all of the research questions, and instead only discussed research questions 1 and 2. As was explained in Section 4.3.2.1., it was deemed more valuable, giving the epistemological and ontological assumptions being made in this research, to collect a greater depth of data into one research question as opposed to collecting more superficial data about all research questions.

5.3.1. Case 01 – Track and trace pilot in the beef supply chain

Case 01 concerned a public health standards organisation which were seeking to improve their beef supply chain. The project was a pilot which was used to evaluate the capabilities of blockchain technology and the beef supply chain in the UK was identified as the preferred location for the project. The project aimed to track beef goods from source to consumer. This involved deploying a blockchain, supported by additional technologies, in order to collect and store data which could be used to identify the origin animal, the conditions of the animal, and to track the meat produce as it moves through the supply chain – in relation to the original starting animal. This project was needed due to the large quantities of fraudulent meat produce which was passing through the supply chain which could present a risk to human health as well as being financially unsustainable. The organisation was a large multinational and thus had global operations. The organisation was described as large and slow moving by the interviewee due to the extensive bureaucracy and complex legal requirements facing the organisation as a result of the safety critical produce and the multi-geographic operations. The Deployment Lead organisation had sufficient levels of cash for the project and financing was described as being easy to establish. The project started in 2017 and thus there were fewer external examples of blockchain in supply chain use cases than there are currently.

5.3.1.1. Case 01 – Interviewee description

The interviewee held a consultancy role in the project and acted as a project manager for the project. This involved speaking to stakeholders of the project - within and outside of the Deployment Lead organisation -, as well as developing the strategic approach for deploying the blockchain technology. The primary stakeholders of the project were the IT department, the CIO, the finance departments, and the supply chain members. The interviewee

explained how power, in relation to this project, did not necessarily correlate with the highest-ranking management. For example, the CEO was trusting of the CFO, and as a result, the project seemed to hinge on the approval of the CFO as the CEO was willing to back the project if the CFO approved. The CFO also had influence on other employees outside of the finance department as the CFOs enthusiasm for the project was cited as influencing the IT department, as well as the finance department, to support the project.

5.3.1.2. Case 01 – Investigation Phase

The project initially went through an investigation phase. The interviewee explained how the investigation phase had two main functions: (1) Firstly, the investigation phase was used to convince all of the relevant stakeholders to go forward with the project. The interviewee described how there was a conflict at an upper management level as innovation is something which was often discussed amongst the upper management, however the interviewee noted how they were simultaneously afraid of it due to the associated risks and aiming to avoid accountability if something were to go wrong with the project. The consultant explained how fear of missing out became the driver that convinced the management to give the project the go ahead. The interviewee also explained that there was interdepartmental friction. The IT department had a history of requesting large sums of money from the finance department and there was a previously established friction as a result of the finance departments scepticism of the IT departments lower financial requests. (2) Secondly, the investigation phase was used to establish the aim of the project. When the project was initially started, the objective was to see if there was any value to using blockchain in a supply chain. This could reflect the time period as there were fewer external examples and established use cases of blockchain in supply chain. Through this investigation, track and trace was established as a useful application of blockchain which could add value to the supply chain. This was due to existing difficulties within the supply chain – product certification and fraudulent products. Thus, the specific project aims and objectives emerged at this stage of the project. In order to alleviate the risk averse attitudes of some of the upper management and to secure funding for the project, the participant

explained how he identified where the power lied within the organisation, and then put effort in to influence this individual (CFO). This relieved a lot of the interdepartmental conflict that was occurring within the organisation whilst simultaneously getting the backing of other members of C-level management.

5.3.1.3. Case 01 – Deployment phases

Following, the project moved into deployment phases. This started with a proof-of-concept (POC). The POC was used to prove out the technology could function as intended. The interviewee explained how technical issues were not overly prominent at this point; however, there was conflict between the IT department and the Consultant. This conflict was a result of the participant recognising that the IT department lacked the blockchain competencies necessary for the project, whilst the IT department felt that they should build the blockchain internally. The interview later adds that this was resolved by allowing the IT department to try to build the blockchain internally, before bringing in blockchain specialists to build the blockchain once the IT department realised they were incapable of building the required blockchain. Notably, the participant described the IT department as feeling ashamed that they were unable to build the solution. Finally, the project was transitioned to a pilot phase. The pilot phase was used to establish the value that could be realised for the network as a result of the blockchain. This involved deploying the solution and to onboard all of the relevant stakeholders to the network.

The interviewee discussed several barriers to the deployment of the blockchain throughout the supply chain within the case. The two main issues which were discussed were data collection and supply chain onboarding to the network. Collecting accurate and assured data was paramount as the blockchain project was a response to fraud within the beef supply chain. The fraud was occurring in several ways such as having cows killed prematurely to reduce costs whilst being sold as more mature cows; and having cuts of premium cows mixed with cuts of cheaper cows but being sold at the premium rate. Thus, there was a need for each cut of the original cow to be identifiable and linkable back to the original cow, as

well as having additional data which could be used to verify that the cow meets the agreed upon criteria. Thus, there was a need for multi-factor authentication to collect assured data that would inhibit the ability of bad actors to commit fraud. This involved collecting a variety of different data inputs in order to authenticate the animal and the cuts of beef. This included a DNA sample, GPS data of the animal's location, breed authentication data, and age authentication data. The animal also had an ear tag and the farmers had an app that they could use on their mobile phones to scan the ear tag. The interviewee explains how this need for, as close to, 100% assured data was very challenging to automate and to have the data collection be technologically accessible for the farmer. The interviewee explained how the majority of these technical challenges were solved by perseverance and time. However, one specific issue was with the fact that some of the data which was pulled from other sources and used for the multifactor authentication, was not possible to automate as it was held by a 3rd party, who used paper-based systems. Thus, there was no real solution for this besides encouraging the 3rd party to automate their own processes.

The second main issue which faced the project was onboarding supply chain members to the blockchain network. This was necessary in order to be able to capture the data which is required for the network to function. There was initially resistance to join the network from several stakeholders for varying reasons. To overcome this, an individualistic approach was undertaken that centred around identifying how different supply chain members could be incentivised to join the network. For the farmers, this was by improving the price which was paid for the cow. When the deployment lead had a level of access to data that enabled them to know that the cow was what it was marketed to be, they could pay a higher price to the farmer and increase the farmers margins as there was a level of certainty about what the product actually was. Alternatively, retailers in the supply chain spend large sums of money trying to verify that the beef is the same as is advertised. Thus, to incentivise them to join the network, the verification was automated and moved upstream, removing the financial burden for verification from the retailer and improving their bottom line.

"Farmers are very practical people. What's in it for me? They're practical people. It was an interesting conversation. So, part of what I did in the first three or four months was I didn't do very much except talk to the stakeholders, talk to the farmers, and then talk to the

abattoirs and then talk to the retailers who buy the meat. Listening and listening more… The thing that I found what made the difference was a conversation I had with a farmer in the field. A lot of farmers don't make any money. There's very little margin, if any, and often a negative margin on beef. Because of the way the supply chain works there's very little margin. Lots of problems with it and not making any money. The pitch was, if I can improve the gate price of your cow, and I can do that, would you be interested?" – Interview Participant 04, Case 01

5.3.2. Case 02 – Track and trace pilot at a European Port

The blockchain project started without any real direction other than to explore if blockchain can provide any value to the deployment lead or their clients. After a series of proof of concepts which served to establish if there was any value for the supply chain, the project moved onto a pilot. The blockchain objective went through several iterations but ultimately it was a track and trace blockchain with the view to adding supply chain finance functionality as well as some additional trade finance functions such as notarising events, generating invoices, triggering payment conditions, and certifying ownership and insurance. The deployment lead was a consortium of the members of a supply chain and was based around a specific port where goods would enter and leave the country. The consortium was not a distinct legal entity but it included individuals from several of the involved organisations. The primary stakeholders of the project were those that formed the consortium. This included a bank, a port, and a tech provider. The secondary stakeholders of the project were the participants of the port and the logistics network which the blockchain aimed to serve – this included the shippers, the logistics service providers, and the receiving parties. The track and trace functionality of the blockchain was for land and sea freight. This was achieved by using GPS on the boat, and on each container within the ship, and on the trucks. Off chain events would then generate events on chain which related to invoicing, ownership, letters of credit etc. The blockchain also featured IoT devices to track data relating to the container's conditions, such as temperature and humidity, that could also trigger events on chain.

The blockchain project was unsuccessful in that it never reached production grade and several of the members pulled out of the project – Including the deployment lead organisation of the interviewee. Currently, the port are still working with blockchain and they have established a new consortium of partners and the main focus is on dealing with trading issues as a result of Brexit. The original deployment lead organisation of the interviewee is no longer involved with the project and as a result, this new project is not a part of this case study.

5.3.2.1. Case 02 – Interviewee description

The interviewee worked at the deployment lead organisation and was the lead of the unofficial consortium of organisations within the supply chain which were seeking to deploy the blockchain solution. The consortium was not a distinctly separate legal entity; however, it did operate in a similar way despite not legally existing and had representatives from several organisations. The participant played a strategic role and was concerned primarily with establishing a vision from the project and the various use cases which were developed throughout. This extended into establishing the off and on chain governance, developing the road map, communicating between departments and organisations, establishing what technologies would be supporting the blockchain, and how the blockchain should operate.

5.3.2.2. Case 02 – Deployment phase

The first phase of the project was an Investigation phase to establish the value that blockchain could bring to the port and the stakeholders. However, the majority of the issues which were discussed occurred at when trying to deploy the blockchain solution. As a result, this section focuses on the deployment phase before circling back to the investigation phase in order to highlight some best practices. Following the investigation phase, there was a series of POC's to test the technology. Notably, there was still some degree of establishing the value at this stage as can be evidenced in the multiple iterations and objectives of the

technology stacks which made it to POC. The following phase was a pilot; however, this phase was not completed due to consortium members withdrawing from the project.

The interviewee notes how throughout the project there were several issues which caused conflict between the consortium members. However, the majority of these issues can be considered collaboration challenges. Whilst the interviewee acknowledges that the objective of the blockchain was agreed upon by all consortium members, the participant notes how it often felt like each member had their own vision for the project and that this led to conflict between the consortium members. This manifested in funding challenges and the rules of engagement as there was no long-term ruleset for participation defined at the outset. This meant that funding for each stage had to be continually negotiated and that different members felt like they only wanted to fund parts which directly pertain to them. This caused conflict between the members. Similarly, the rules of engagement within the governance of the project was also subject of negotiation frequently. Thus, the consortium was pulling in a variety of directions and at times was operating as three distinct separate firms with their own interests as opposed to operating as a single entity. A lot of these points of negotiation would then be discussed internally by each of the three organisations, who each had separate timelines, and this would then lead to further misalignment of the consortium members.

"That creates a little bit of an issue because if you would have defined, okay, now we have the next stage gate and we want to achieve this, and then afterwards we want to achieve this and we require X amount of money for this to go to the next point, then there would be always a deliberation again - is this really right? Do we need so much? Where does the money come from? So, then it has to be divided over the three countries and they may have different insights and interests at that moment, so they say now we will not pay one-third, for instance, but we're only interested to paying 20% of it." – Interview Participant 7, Case 02

The interviewee continues by explaining how there were some cultural differences between the consortium members which also caused some issues. He states that most of the

members were European organisations; however, the tech provider was an East Asian company. The interviewee noted how the East Asian company were not very open-minded in how the technology should be deployed and that this created friction. The interviewee goes on to describe how the trust eroded with the Large multinational tech organisation as they would often say one thing and then do another.

"There was complete trust between the three parties but the Western European Country representatives, so to say, of Large Multinational Tech Organisation we had to be connecting all the time with Large Multinational Tech Organisation, and that I think was creating in the longer run an issue because of differences in culture." – Interview Participant 07

The interviewee also recognised that there were legislative challenges which impeded the deployment. At the time of deployment, international trade required a wet signature or time stamp on some of the documentation. This proved contradictory to the aim of the blockchain which was to automate these procedures and as a result, some automation was not possible. Similarly, as the blockchain was operating in several countries, the blockchain, the contracts, and the documentation which it was aiming to generate, had to be compliant with many different laws. The products required certain information to be shared by one jurisdiction that was simultaneously regulated by another which caused delays in establishing the legal requirements first, before they could be developed in the form of executable smart contracts on the blockchain. This finding is in accordance with some of the cases within the Clohessy & Acton (2019) study. In their study the authors found that lack of government support was an inhibitor of adoption. However, they also found that in 75% of the cases where blockchain was adopted, that external pressures actually encouraged the adoption of blockchain technology. Which is a finding also echoed in this research.

"Technology normally can solve anything very easily but then the rules and regulations are behind. That was the biggest issue we had because you also had to share information of the borders and then sometimes now you have all kinds of new regulations which make it more difficult to share actually information of the borrowers" – Interview Participant 07

At the outset of the project there was a shared vision to an extent, however, the interviewee felt this was never communicated clearly and that it wasn't as thorough as it should have been. One example the participant gave was in how the blockchain solution would be provided. The tech provider wanted to provide the solution whilst other members did not feel the tech provider had the capability to provide the required solution and each member had their own IT departments or blockchain subsidiaries with their own interests and views. Ultimately, this was cited as the reason why the project was never fully realised as several of the members pulled out of the project.

"I think there has been too little attention to what is the shared vision, what we want to achieve in the short run to make really progress but also the controls, what are your thoughts and what are your responsibilities, and that you could actually come back to that. You can always change and adjust them but you should start at least with an initial one and I think that was not outspoken clearly, especially with expectations" - Interview Participant 7, Case 02

The technology provider within the consortium dropped out of the project as they wanted to use a different technology stack than what the other consortium members wanted to use. The interviewee attributed this to the IT departments at the other consortium members firms whom believed that using the technology providers technology stack was not the most well suited to the project. After the tech provider had left the project, the bank then revaluated their strategy to be less focused on the port, and ultimately the bank then followed the technology provider in withdrawing from the project. The bank didn't see the value that blockchain technology could add for them and they were reluctant to change business model and invest in blockchain when they couldn't see the value it would offer them. The interviewee notes how the bank were predominantly interested in lines of credit whereas he believes the bank should have been more focused on the supply chain finance benefits and ECG reporting.

When the interviewee was asked how would he approach the project differently if afforded the luxury of hindsight, the interviewee stated that the main difference in approach would

be to legally establish a separate entity. This is something they were trying to do around the time the project ceased; however, he believes this should have been done at the outset of the project. Further, in doing this he would establish a long-term funding commitment from each of the members of the consortium within the governance so that there would be no need for continued renegotiation of funding as that was a great source of conflict between the members.

5.3.3. Case 03 – Production-grade blockchain in a pharmaceutical supply chain

There are several use cases of blockchain technology at Large Pharmaceutical Organisation which the interviewee is working on. Some of these blockchains are developed internally whilst others are developed externally. The Large Pharmaceutical Organisation is also a part of external consortiums of pharmaceutical organisations which have industry wide objectives as opposed to being focused solely on Large Pharmaceutical Organisation. The blockchains objectives vary between project; however, the interviewee focused predominantly on the track and trace blockchains. The blockchains were generally all consortiums of distributors, clinics, hospitals, and the Large Pharmaceutical Company. As of 2020, Large Pharmaceutical Organisation have blockchain projects which have moved beyond pilot and are now in production grade where they are scaling the systems by onboarding more members and/ or expanding into other product lines. Thus, the track and trace blockchain projects are usually orientated around one specific product line initially and then additional product lines are added at later stages. The interviewee explained that when deploying a solution in an additional product line there is a degree of customisation as different products have different needs and complexities. The participant explains that, in Large Pharmaceutical Organisation and the pharma industry as a whole, 95% of revenue is usually coming from 5-7 flagship product lines, and that these product lines are the ones which are prioritised by blockchain projects as these offer the most value and as a result are

the most in need of protecting from counterfeiting. The long-term goal is for the blockchain to cover all product lines within the business.

5.3.3.1. Case 03 – Interviewee Description

The participant has experience working on developing the blockchain technology and is now in a role where he works on the business side and is involved with the deployment of several blockchains throughout Large Pharmaceutical Organisation's supply chain. The participant has a technical background in blockchain technology and software development, but has since transitioned into the business roles surrounding blockchain technology. The participant is responsible for the strategic vision of the blockchain systems and the teams which build these technologies. The participant is also involved in working with external organisations to develop governance around blockchain technology use in the pharmaceutical industry. Due to the limited time the interviewee could commit to the interview, the interview focused on barriers to blockchain deployment in depth, as opposed to discussing barriers and best practices in a superficial depth. Thus, the interview was primarily concerned with understanding research questions 1 and 2 in the context of a production grade pharmaceutical supply chain use case.

5.3.3.2. Case 03 – Deployment Phases

The interviewee explained the deployment process for the blockchain projects within Large Pharmaceutical Organisation. The deployment goes from POC, to pilot, and to production. The interviewee states that the objective of the POC is to test the technology. The purpose of the pilot is to then test the technology with a restricted group of users. At this phase it is necessary for the business processes to adapt to the new collaborative ways of working with the blockchain. Following the pilot, the blockchains were then deployed at production grade with a greater number of users required for the objective of the blockchain. Lastly, once the

blockchains were scaled throughout a product line, additional product lines, capabilities, or users were added to the network. The interviewee also stated how the pilot is the point where the majority of issues occur as it is the phase where business processes are adapted to the technology and members are onboarded to the blockchain.

"you start with the proof of concept then you probe it on a restricted group of users in a restrictive ecosystem within a pilot and then you go with an MVP and then you go keep on iterate and develop and move forward." – Interview Participant 13, Case 03

Due to time constraints of the participant, this interview was shorter than the other case interviews and as a result less topics were covered than in the other interviews. However, the interviewee did explain several challenges which they faced when deploying their blockchains. The participant stated that they faced two main technological challenges throughout deployment – (1) integration challenges and (2) blockchain platform challenges. Specifically, the participant said that designing the blockchain to integrate with the legacy systems of the supply chain members – distributors, wholesaler etc – is difficult as there were a wide variety of different legacy systems which need to integrate with the blockchain in different ways. Thus, the blockchain system needs to be versatile in the types of legacy systems which it can pull data from and push data to, as it is unlikely that each stakeholder of the blockchain system is using the same software. As a result, the data will be in a variety of different forms and the interviewee cited difficulties in developing the blockchain to accommodate these varying legacy systems. The second issue currently facing Large Pharmaceutical Organisation is in the type of blockchain platforms which they are using. The interviewee stated how currently they are operating using private permissioned blockchains. However, he went on to add that there are some developments with public permissioned blockchains such as sharding and layer two solutions. Thus, he anticipates that there will, in the near future, be a need to transition from private permissioned blockchains to public permissioned blockchains which use layer two protocols. This would increase the value of the blockchain; however, it would make the maintenance more complex if trying to keep up with all of the live updates to the public blockchain being used. The participant

does acknowledge that this is a good problem to have as it shows the development of blockchain technology and if they do decide to switch from private permissioned to public permissioned then it will be to because public permissioned is offering more value than private permissioned.

"So, I will kind of avoid to give names at some point. At this time. But normally we are looking at it in the way the industry looks at it right now for corporate use. It's around private permission blockchains. Those are for a couple of reasons the best fit. The problem that we have and I'm not sure if I can call it a problem so maybe it's fortunate or it's fortunate at this point is the technology's evolving. So, it's not yet a mature technology. And if you look now for example what public blockchains have the promise to achieve with sharding or with layer two solutions. I think it's very significant and in one year from now things will change so corporate would make more sense to move into using public blockchains with layer two solutions on top. But you have to start small and just keep the pace with the latest advancements." – Interview Participant 13, Case 03

A similar issue was discussed by Interview Participant 13 who found that different countries used different standards for product serialisation. As a result, it presented a challenge in determining how to account for the conflicting standards in one blockchain system that used standards as digital anchors for products. Lastly, several interviewees spoke about how specific countries, such as China, have specific legal requirements concerning data and data access that can cause conflict with organisational policies around consent for data disclosure. In this scenario, data conflicts could occur with competitors having access to your data and/ or governments having access to the data which may be an issue if the supply chain members and the deployment lead do not consent to this disclosure. In their study on blockchain adoption barriers in agri-food, Zhao et al. (2019) found legislative challenges to be one of the 6 most prominent barriers to blockchain adoption. However, they cite the lack of regulation as the primary issue in their discussion. They continue by recommending the need to address legislation from a global perspective as the solution. Lack of governmental policies was also a predicted barrier in Saberi et al. (2019). Whilst not being specific to the legislative issues, legislative challenges were also noted as a result of

the literature review into blockchain adoption in the supply chains by Duan et al. (2020). They stated that regulations are out of date and do not match the position of blockchain currently. This is echoed in the edited preface of Tapscott & Tapscott (2018) where they called for greater regulation of the technology, conflicting with their stated desire for minimal regulation a couple of years prior. This was due to the belief that in the technology's infancy, limited regulation would allow for greater developments whilst in 2018 the technology needed regulating due to its increasingly mainstream adoption and the resultant need to protect users. Thus, given blockchains infancy relative to other more established technologies, regulatory challenges are more fast moving and this can be exacerbated when dealing with multiple geographies. This is a finding also found in the literature review study of Yadav et al. (2020). The research found that 'lack of government regulation or regulatory uncertainty' was the most prominent driver barrier to blockchain adoption. This led the authors to conclude that this is one of the key challenges facing blockchain adoption and that it is one of the barriers which must be addressed first as this issue is having a mediating effect on other issues. Thus, the scholars suggested that government and regulatory bodies should work to produce regulatory guidance on blockchain use. The authors continue by suggesting that this could be done as a collective agreement between UN countries.

"Another thing it's what type of data you can collect from specific countries. In theory, this is fine if you kind of I'm talking globally. I'm not referring to a market. There might be some special practicalities if you talk about China. Things there are very different. But in theory in the rest of the world with the user consent or with the consent of the user and the parties involving collecting data, you can collect data if you can get consent." – Interview Participant 13

The interviewee also discussed some challenges which were external to Large Pharmaceutical Organisation. The pharma supply chain is global and as a result the supply chain of one product line is often operating in several countries. These countries each have their own legislation and standards which Large Pharmaceutical Organisation need to

adhere to. The interviewee stated how it is difficult to digitally anchor a product using the bar codes and serialisation as these vary as you move between jurisdictions. Further, within the same supply chain, there are some geographies where the product is serialised, whilst in others it is not serialised. Thus, you no longer have access to the digital anchor. To alleviate this issue, Large Pharmaceutical Organisation are doing voluntary serialisation where you serialise a product even in jurisdictions where no serialisation is required. The issue here is that this increases the complexity of the blockchain system. Lastly, the participant also discussed how onboarding users into the governance and gaining access to data is an issue which they faced in each of their deployments. For example, the participant talks about how when they deploy track and trace blockchains, this requires the manufacturer, distributors, wholesalers, and pharmacies to be onboarded into the governance. Thus, to have full traceability of each of your products, each supply chain member needs to have provided access in order for valuable data to be captured and uploaded to the blockchain. This implies that the supply chain onboarding and gaining data access is more challenging than adding additional functionality to the blockchain.

5.3.4. Case 04 – Production-grade blockchain in real estate

The blockchain aims to connect the various parties involved in the sale of property in the UK. The blockchain objective is to reduce the duplication of work for each of the members of the property supply chain and to speed up the housing transaction process by creating a central database of truth about the housing transaction. In its current state, estate agents and conveyancers are on the live network. The current plan is to eventually expand this to include other stakeholders of the property transaction, such as lenders, brokers, consumers, and property advisors on the network; before eventually adding new build construction organisations to the network. At the time of evidence collection, the blockchain was live in just the UK; however, there were plans to launch in an additional country in early 2023. Each stakeholder group interacts with the blockchain through a web app or a customer relationship management system. The blockchain is a private permissioned network.

5.3.4.1. Case 04 – Interviewee Description

The interviewee has a technical background in software and has been working with blockchain technology specifically for over two years. The participant is still in a technical role, but also has management responsibilities. The interviewee explains that their responsibilities include leading the team, designing the blockchain, and liaising with the customers. As a result, the participant can provide insight into strategic decision making, technical challenges, and customer related challenges. The participant works for the technology provider organisation.

5.3.4.2. Case 04 – Deployment Phases

At the time of evidence collection, the blockchain had been live for over a year. The project was initially developed to establish if the digital asset transfer of properties could be possible on the blockchain. However, due to legislative restrictions, the objective of the blockchain was shifted several times. This manifested itself as the project undergoing numerous POC phases in order to prove the technology function, whilst establishing the value that they could bring to the housing supply chain before developing this as an MVP. At the POC phase, the team were asking themselves, "what is the minimal functionality that would be useful for an estate agent and conveyancer"? The POC projects involved lenders, but the lenders were not involved in the project when it went live.

The interviewee referenced several difficulties which were currently facing the project and which have previously faced the project. Some of these challenges were business related whilst others were technology focused. Without being asked, the participant noted how onboarding stakeholders to the network is one of the hardest challenges that they face. However, he goes on to differentiate these difficulties by demographic; reasoning that different stakeholders present different challenges to onboard into the network. The participant explains how estate agents and conveyancers are currently the two stakeholder groups on the network. This is because they are the easiest to onboard as they have less

bureaucracy than some other stakeholders, and as a result they don't have as many checks and technical challenges as a lender for example. The interviewee continued by explaining that the majority of these challenges, and the majority of challenges generally, occur at the scaling stage. The rationale provided was that as you scale, the number of opinions increases and sometimes these opinions are very strong. This is where the hurdles develop as you are already invested into one road map, and it could become evident that that road map is conflicting with the opinions of some stakeholders.

"[Scaling and onboarding is difficult] because when you put things in front of people is when you get that variety of feedback and you realise your assumptions were wrong. In the POC stages you will have some stakeholders you're working with but it's a limited number. So, as you get more and more, as you scale it, that's when you get this very wide variety of opinions. It throws up way more issues, let's say, as they all have different takes on how something might or should look. And sometimes those opinions will be quite strong and they'll have a belief that, it might be a legislative restriction, that they have to do it this way" – Interview Participant 02, Case 04

In an attempt to mitigate some of the issues faced when onboarding prospective members to the network, the interviewee explained that they have been trying to onboard pairs of estate agents and conveyancers which commonly work together. This increases the number of estate agents and conveyancers on the network whilst ensure that all the relevant stakeholders are on the network. This is an approach which may be industry specific but could have some applicability outside of real estate in some niche circumstances. The participant also noted how when onboarding stakeholders who have limited IT resources, the tech provider is often forced to host and run the infrastructure. This increases the costs of the technology provider. Further, because the stakeholder has a small IT department, this often means they are a smaller company and thus there becomes less of an incentive to onboard them onto the network as the value they offer is less whilst their costs are higher for the tech provider or deployment lead organisation.

The interviewee also reported on some technical challenges which they have faced. Notably, one of these technology challenges also exacerbated supplier onboarding. The interviewee explained that it is currently not possible to standardise the integration of the blockchain with the legacy systems being used by the stakeholders. As a result, there are several challenges in pulling and pushing data from and to these varying legacy systems. In some instances, the participant explained that these challenges can lead to the blockchain not being deployed with certain members. In some circumstances, the integration is done by the organisation trying to join the network and in other circumstances the integration is done by the Technology Provider organisation. The interviewee also reasoned that the main issue inhibiting their ability to scale the blockchain is due to the infancy of the technology. This seemingly manifested in several ways throughout the interview. Because of the infancy of the technology, the participant explains that when the participating organisation have an error message, often the technology providers do not understand it and that they have to work hard and dedicate a lot of resources to understanding the error so that they can fix it. This is laboursome and it increases dissatisfaction of the stakeholders of the network and can create friction. Alternatively, when the stakeholders are hosting infrastructure and their own node within the network, they have to continually update in order to be compatible with the blockchain updates made by the technology provider.

Lastly, the interviewee also explained an issue related to asset specificity and the opportunistic behaviour of those on the network. In order to incentivise a conveyancer to join the network, the technology provider invested in integrating the conveyancer into the network and they were able to refer business to that conveyancer as an incentive to join the network. However, the conveyancer then left the network but kept the referred business as they had established business relationships with their new customers. This is an example of the technology provider investing specific assets into the relationship with the conveyancer and the conveyancer then behaving opportunistically to take advantage of the circumstances.

“One of the first conveyancers we had on the network, we would refer quite a lot of business to them and we were becoming the matchmakers basically. So, we got estate agents on the network and we'd say, hey, use these guys. That turned out to backfire a little bit, let's say.

Basically, we've referred so much business to them they could be almost self-sufficient in creating those relationships themselves now." – Interview Participant 02, Case 04

5.3.5. Case 05 – Telecommunications infrastructure leasing POC blockchain

The project was led by a consortium of organisations which aimed to establish a network where competing telecommunication companies could lease infrastructure to one another in order to improve consumer experience and access to telecommunications. The project aimed to produce a self-healing, zero touch, blockchain that would use smart contracts to automate the production of all of the relevant contracts, and would be able to accommodate breaches of said contracts into the payments. The project was a proof-of-concept at the time of the participants involvement so the objective was to get the technology to Technology Readiness Level 4. As a result, the project did not have any real-world users; however, it was being designed with this in mind and so can still offer insight into how the users are considered in this type of blockchain deployment. The project started in 2020 and was based in Europe. A consortium of telecommunication deployment leads was established and these were the primary stakeholders of the project. There were also regulators who were involved in the project as it was the first of its kind and they had their own interests separate to that of the consortium. There were also various technology provider organisations who were providing technical infrastructure and consulting services to the project. Lastly, there were Universities who were also involved in the project in a research capacity.

5.3.5.1. Case 05 – Interviewee description

The interviewee worked at a start-up technology provider organisation as a technical architect for blockchain solutions. The interviewee was the lead blockchain architect at the

technology provider organisation. This role involved consulting and delivering on the blockchain related aspects of the project, whilst also communicating with the other technology providers and the consortium of deployment lead organisations.

5.3.5.2. Case 05 – Deployment Phase

Perhaps as a consequence of the infancy of the project, the majority of the issues faced which were described in the interview were technological in nature. However, the participant did state some business-related issues which were also barriers to the project. The interviewee noted how each stakeholder group had their own objectives and what they wanted to get out of the project, as well as the collective objective. The interviewee later stated that he didn't think the competing agendas were "detrimental per se", but went on to acknowledge how these competing interests created friction. For example, the regulators were interested in the concept of leasing bandwidth as this could have implications at a legislative level. The technology providers each had their own motives for the project. The interviewees organisation wanted to prove some technologies that would have applicability to other parts of their organisation outside of the project. Other technology providers were invested in winning these types of funded projects, but according to the participant they did not prioritise them once they had won the funding. The interviewee referenced the technology providers dedication junior staff to the project as opposed to senior staff as evidence of this. Some other Universities and organisations were involved which had their own R&D interests as a reason for being involved in the project.

"I think it was clear to see, to me anyway, that there were certain partners that were involved in the project because they got a big load of cash out of it, but then the people you were dealing with, in terms of the devs you were dealing with, were clearly quite junior… You've signed yourself up, you've bid for this big chunk of work, how are you going to make the most out of financially if you don't really have too much of a vested interest in what the

actual result is going to be? You stick your junior people on" – Interview Participant 01, Case 05, 41.20

The interviewee discussed many technological challenges which were facing the deployment of the blockchain. When asked the open-ended question about what problems the project encountered, the participant explained that integration issues were the main issues that faced the project. The interviewee noted that there were several technology providers which each had the responsibility of developing their specific part of the technology, and that these separate parts which were developed separately, were then integrated together at a later date. This proved very challenging as the separate organisations were making assumptions about the technology being provided by the other organisations. In some cases, these assumptions were incorrect and as a result the technologies were not compatible. Whilst these integration challenges were empirical outcomes, the interviewee cited several underlying causes which contributed to the poor integration. Firstly, the participant stated that the main issue he had with the project was in the project management approach which was been undertaken by the lead of the project. The project lead was employing a waterfall management strategy to coordinate the deployment. The interviewee saw this as problematic as he felt an agile approach would have been better suited to the project. He felt that the waterfall approach did not address issues which occurred earlier in the project and these errors persisted further into the build and had a knock-on effect which caused more disruptions later in the project. Secondly, whilst not explicitly stated, the participant also implied that communication between technology providers was poor. This is because in one of the examples the participant gave when probed on integration issues, he explained that there are a set of standards around describing telecommunications resources. The interviewee described these standards as complex. Each technology provider was having to interpret these standards, and the discrepancies in these interpretations was one of the reasons why the integration was running into challenges. Further, the interviewee later referenced language barriers as a hurdle as well, despite acknowledging that the non-native English speakers spoke well around the technology specifically. Lastly, there were several quotations that suggested a

strong lack in competence-based trust between the interviewee's organisation and the technology providers they were trying to integrate with.

"You then had people going away and defining workflows that involved their system and yours in the middle and they'd come back to you and go, this is what we're going to do. It's like, no, no, no, it won't work because... There were big misunderstandings in what oracles were, which is fair enough. It's all new stuff. So, I would say it didn't surprise me that it took the best part of 15 months to come to some form of specification that I didn't honestly think would hold water but was a decent stab at something that looked like it might." – Interview Participant 01, Case 05

"And then once it actually came down to being present, in terms of whether that was at meetings or providing quality dev or writing up decent specs, that you were always chasing the same people or you were always having to have, let's say, almost mentoring conversations with more junior developers on the other side of the fence just to help them do the other part of what you needed from them." – Interview Participant 01, Case 05

Both of the above quotations suggest a lack of competence-based trust; however, this occurs in different ways. The former suggests that there was a lack of competence-based trust concerning the other technology providers blockchain competencies, whilst the latter suggests there was a lack of competence-based trust in terms of communication and cooperation. The lack of competence-based trust could be a product of the other issues raised by the interviewee in that the funding was won and that the winners of the funding did not have "vested interest" in the outcome of the project so dedicated fewer resources and technical expertise to the project.

The participant also explained how the infancy of blockchain technology was itself a challenge. Because of its novelty, some capabilities of blockchains which were planned for release, had not yet been added at the time of the project. As a result, the consortium had

to develop and build their own blockchain functions, despite knowing that these functions were planned by the blockchain provider.

"So, that is a prime example of something we could have identified early and then made a call that either we change our tack to choose a different ledger, etc. But it would have been two years in. It's a bit late to start backtracking at that point, so then it's a case of, well, our thing over here works like this, let's sit down, and essentially we had to start plotting out equivalent protocols for that DLT and manually writing them which, when you know it's coming but it's not available yet, is not ideal." – Interview Participant 01, Case 05

The interviewee also commented on the decision-making challenges when deciding between the various blockchain platforms. He noted how each blockchain platform has its own respective strengths and weaknesses and that when working as a technology provider in a large blockchain project, a large quantity of time was spent in researching these various strengths and weaknesses in order to choose a solution which was the best fit for their specific circumstances.

"But essentially that was a big chunk of the research that we did in terms of making sure that we chose a ledger that wasn't just data sensitive actually. I guess there are trade-offs with any ledger in terms of the governance side of things and being able to have identifiable legal entities." – Interview Participant 01

The interviewee also noted several contractual challenges which were facing the project which are specific to this case. As the project aimed to create network slices which were in several countries, there was a need for this to be built into the contracts produced by the blockchain. This proved challenging as different jurisdictions have different legal requirements. Similarly, the objective of the project was to produce a self-healing zero touch blockchain network for the leasing of telecommunications infrastructure. This would be achieved by having a pre-approved set of contracts which can be activated by a

consumer on short notice and are already agreed to by the telecommunications organisations. However, the contracts did allow for some flexibility within the contract and this was an issue which had not been resolved strategically in terms of how to build in this flexibility.

5.3.6. Cross-case analysis of findings

Irrespective of whether the participants were discussing an atypical case or a typical case, there was a degree of consensus between the interviewees around the project phases when deploying a blockchain throughout a supply chain. All of the interviewees outlined a proof-of-concept as the first deployment phase; and if their project had gone to pilot then they included pilot; and if it had gone to production then they included pilot and production. However, divergences occurred between participants in two main ways: (1) the inclusion or exclusion of an investigation phase, and (2) the specific objectives at each of the project phases.

Case 01 and Case 02 both started with an investigation phase before moving to the deployment of the blockchain. Each interviewee stated that the objective of the investigation phase was to establish the aim of the project by establishing what value blockchain could bring to their respective supply chains. However, interviewee participant 4 explained how in his case there was an additional objective at the investigation phase and that was to establish funding for the project by convincing the relevant decision makers to back the project. Whilst not explicitly stated, Interview Participant 13 in Case 03 did state that the POC objective was to prove the technology functions. This implies that there was a prior decision about the objective of the project which occurred before the POC, otherwise it wouldn't be possible to assess whether the technology functions as it is intended to do so. However, cases 04 and 05 are atypical. One way in which these cases are atypical is that they both originated as funded projects and thus, there was never a need for them to start with an investigation phase as this had already occurred by the original funding body. As a result, in the typical cases it is either stated or implied that there was a degree of

establishing the potential use case and the prospective value add of blockchain technology before moving to proof-of-concept. Meanwhile, in the two atypical cases which were used in this study, there was no need for this phase as the objective and use case had already been established prior to their organisation's respective involvement in the projects.

The proof-of-concept phase was the stage which had the largest degree of consensus between the cases. Each of the involved participants explained that the objective at POC was to prove that the technology functioned as intended. The only differences were that in Case 02 and Case 04 as there was a continued period from the investigation phase where the involved organisations sought to understand the value which blockchain could add as well as looking at alternative use cases. Thus, in some instances the POC was used to extend the rationales, through continued information gathering, which were developed during the investigation phase or during the initial grant funding period. Case 04 is an atypical case because of its legal requirements that come as a result of the large quantities of money involved in the transaction, and the number of stakeholders involved in the transaction. Case 04 deals with property transactions which have a large number of stakeholders which are each subject to strict legal requirements. This is potentially evidenced in the need for Case 04 to involve select supply chain members and stakeholders in their POC to ensure they are developing the technology according to maximising value for the stakeholders whilst also being complicit with each stakeholders' legal requirements. As can be evidenced in the following quotation, the Interview Participant notes how they are working with specific stakeholder groups to build additional functionality onto the network, through POCs, to ensure that it offers value to the supply chain members. This took the form of trying to establish what the minimum viable product was that offered value for the stakeholders and then trying to build this functionality for the stakeholder.

"[On next steps for the project] *So, it is to start getting the larger lenders on the network now and that is going through a couple of sandbox areas that we have for them to try things out and for them to surface things that would make them come on board with the network. What are the things that solve problems for them from an operational perspective?*" – Interview Participant 02, Case 04

This is actually something which Interview participant 02 notes was very difficult, despite working with the supply chain members early in the deployment process. During the interview, Interview Participant 02 recalls finding out about stakeholders of the housing transaction which he had not heard of. Thus, in supply chains where there are a lot of stakeholders and a large amount of complexity, it may be difficult to accurately identify all of the relevant stakeholders which you wish to onboard into the network or to identify which stakeholders to work with early in the project to help in the build of the solution.

"*I've worked with a few and you keep discovering new actors in a property... Every couple of months it's like, oh, that company? Why? Why do they exist? They all fulfil different purposes*" – Interview Participant 02, Case 04

Following the POC, all of the participants who completed the POC stated that they moved to a pilot phase. At the pilot phase all of the interviewees explained how they then deployed the blockchain with a group of users. However, this affords a large amount of subjectivity as establishing which organisations qualify for the pilot is up to the development lead or consortium seeking to deploy the solution. For instance, in Case 01 this involved complete tracking of beef from farms through to the supermarket where it was sold to the consumer. Further, this involved several functions as they included multifactor authentication as a means of adding assurance to the network. Whereas in Case 03 this involved tracking a pharmaceutical good as it moved between a restricted group of stakeholders who were on the network. Thus, organisations seemingly establish the scope for their specific project according to functionality, and to number of stakeholders. The interviewee for Case 03 was the most experienced in deploying blockchains throughout their supply chains as they had deployed several successful blockchain projects at a production grade which had a variety of different objectives. Notably, he was the only participant who explained that an important part of the pilot phase, is in adapting collaborative business models to the new ways of working with the blockchain in place. This places a greater amount of emphasis on collaborative practice than the other participants who discussed the pilot phase. Further,

Interview Participant 13 went on to add that this process reengineering of collaborative business operations is one of two main reasons why he believed the pilot phase was the most difficult phase of deployment of a blockchain throughout a supply chain.

"*And that's why I'm saying pilots are essential because then you prove it in a real world what is actually happening and then can slightly adapt. Sometimes it's how things are and also there's small dependencies that if you don't really prove it in the real world, you can't figure it out. Pilots are essential. If there is any take away you can put there in your paper, pilots are essential when it comes to blockchain. The pilot is particularly challenging… [At pilot {I believe he misspoke saying POC twice}] I want to build a supersonic jet. And while doing POC I'll just build a paper plane and just throw it. So, kind of that to show the folks, the stakeholders, what they intended, but the difficult part will come when you actually deploy the pilot*." – Interview Participant 13, Case 03

The final project phase was production. Only two of the interviewees worked on projects which had reached production-grade. The distinction between the production grade deployments and pilot grade deployments is subjective; however, it comes down to scale. Both participants explained that at production-grade you onboard the remainder of the stakeholders to the network that were not involved in the restricted group that were previously onboarded at the pilot phase. Secondly, both participants explained that it is at this phase where you should be adding additional functionality to the blockchain as you already have the access to all of the data you may need as the blockchain has been deployed throughout each of the supply chain members. This is in contrast to Case 02 where the blockchain was never successfully deployed as they completed several POCs but did not get the blockchain to pilot grade. In Case 02 the interviewee explained how the blockchain which they were seeking to deploy would have several functions such as: track and trace, supply chain financing, notarising events, generating invoices, triggering payment conditions, and certifying ownership and insurance. This functionality is extremely complex and seeking to develop this functionality through a series of POCs before having a single function blockchain, such as track and trace, operating at pilot or production grade could

have been a contributing factor as to why the project was never fully realised. As was discussed in section 5.1.2 on Case 02, this may be supported by the participant citing continued negotiation at each round of funding for the project leading to friction between the consortium members.

"That creates a little bit of an issue because if you would have defined, okay, now we have the next stage gate and we want to achieve this, and then afterwards we want to achieve this and we require X amount of money for this to go to the next point, then there would be always a deliberation again - is this really right? Do we need so much? Where does the money come from? So, then it has to be divided over the three countries and they may have different insights and interests at that moment, so they say now we will not pay one-third, for instance, but we're only interested to paying 20% of it." – Interview Participant 7, Case 02

Interview Participant 13 continued to explain that at production grade you can then deploy the same blockchain, because you have the technology functioning, in different product lines. This could be a consequence of pharmaceutical suppliers often supplying several products and as a result you already have access to several members of another product lines supply chain. Alternatively, Interview Participant 02 explains how they are seeking to use the same technology they have already developed and to deploy this in another geography. Thus, at production grade, (1) organisations may look to onboard the remainder of the supply chain to the network, (2) add additional functionality to the network, (3) deploy the blockchain in additional product lines, and/ or (4) deploy the blockchain in additional geographies. Table 19 summarises the project phases that featured within each case alongside the corresponding objectives that the interviewees explained.

Table 19: Project phases that featured within each case alongside the corresponding objectives that the interviewees explained

Case	Project Phases	Objective
Case 01	Investigation phase	Convince stakeholders to go forward with the project
		Establish the aim of the project by establishing the value blockchain can add
	Proof-of-Concept	Prove that the technology functions as intended
	Pilot Phase	Deploying the solution and onboarding stakeholders to the network in the product line
Case 02	Investigation Phase	Establish the aim of the project by establishing the value blockchain can add
	Proof-of-Concept	Prove that the technology functions as intended
		Establish the aim of the project by establishing the value blockchain can add
	Pilot Phase	Not completed
Case 03	Proof-of-Concept	Prove that the technology functions as intended
	Pilot Phase	Deploying the solution and onboarding a restricted group of stakeholders to the network
		Adapt business processes to the new ways of working
	Production	Onboard the remainder of the stakeholders to the network

Case	Project Phases	Objective
		Deploy in additional product lines
		Add additional functionality to the blockchain
Case 04	Proof-of-Concept	Prove that the technology functions as intended
		Establish the aim of the project by establishing the value blockchain can add
		Work with a small number of stakeholders to develop the POC
		Develop the Minimum Viable Product version of the blockchain
	Pilot Phase	Deploying the solution and onboarding a restricted group of stakeholders to the network
	Production	Onboard the remainder of the stakeholders to the network
		Add additional functionality to the blockchain
Case 05	Proof-of-Concept	Develop and prove that the technology functions as intended

The following outlines the challenges which faced the deployment of the blockchain system throughout the respective supply chains in each of the cases. This section also includes the reasons for failure as only one of the studied blockchain cases reached this point. This is achieved by detailing the observed challenge in the empirical as well as stating any underlying causal mechanism which was implied or stated by the interviewees. The section is structured thematically according to the Technology-Organisation-Environment

framework. Notably, the majority of the cases studied experienced technological challenges and external challenges more than organisational challenges.

The most frequent technological challenges which were discussed were related to integration issues. These integration issues manifested predominantly in two ways. Some participants highlighted issues in integrating the blockchain with the existing legacy systems of the supply chain members; whilst others expressed difficulties in integrating the blockchain with the technology stack and other aspects of the blockchain system which were being worked on by other organisations. Case 03 and Case 04 both described the blockchains integration with existing legacy systems as a major hurdle. Integration in this sense involves pulling data from the legacy systems onto the blockchain or pushing data from the blockchain onto the legacy systems. In both cases this can be attributed to the wide variety of legacy system which the blockchain has to integrate with as each system will have the data formatted in different ways which increases the complexity and customisation required to pull or push the required data. Alternatively, in Case 05 integration issues were prominent but they did not manifest in the same way. Interview Participant 01 explained how they struggled integrating the various functions and parts of the blockchain with each other and the wider technology stack. This was a result of various organisations each working on the project. As noted by the participant, this may be a result of the scope of the project, and thus the required technological expertise, being so broad that no single organisation could produce the entire technology stack. However, the participant also detailed issues concerning communication between the organisations as a contributing factor to the integration challenges. Specifically, work was being interpreted differently and having to be redone to ensure that it was capable of being integrated with the technology stack. The continued delays and reworking required at integration could be evidence of a lack of competence-based trust between the partner organisations.

Several of the participants interviewed about a case also discussed smart contract challenges. In the typical case, Case 02, the participant described the difficulties that occurred as a result of the supply chain operating in numerous jurisdictions. This created issues when trying to automate the smart contracts on the blockchain to automatically generate invoices and documentation. Likewise, in Case 05, the participant explained how automation of smart contracts was a challenge when having to generate contracts that can

account for the multiple geographies which the blockchain operates in. Thus, these findings suggest that operations in multiple geographies can be a causal mechanism which increases the complexity of smart contract automation. This phenomenon of increased complexity when operating in multiple jurisdictions manifests slightly differently in Case 03. In the pharmaceutical case, Case 03, the participant explained how the digital anchoring of the products which were moving through the supply chain was an issue. The participant cited the lack of required serialisation for some products in some countries; thus, there was not always a need for a product to be serialised. This meant that it was difficult to accurately refer back to a product. As a result, they developed their own approach to serialisation so that all products were serialised and could be digitally anchored using this serialisation.

In three of the studied cases, issues occurred concerning the infancy of blockchain technology. In Case 03, the participant explained that they originally went with a private permissioned blockchain. However, more recent advancements in public permissioned blockchains which have occurred since they invested into private permissioned blockchains have caused them to question if they should invest in switching to public permissioned blockchains as they could offer more value to the entire supply chain. in Case 05 the participant explained how they were struggling to agree on which blockchain platform to use to build their blockchain solution. This caused friction between the partners as different organisations had different preferences for the build. Likewise, this same phenomenon was the reason why Case 02 was never successfully deployed. The participant explained how the organisations could not agree on which platform to use to build the blockchain and ultimately this caused one of the partners to leave the consortium which in turn caused other partners to rethink their position and commitment to the project. In all three of these cases there is an indecision and uncertainty about which blockchain platform to use. However, in each case this has a markedly different outcome. This suggests that this issue, whilst important to resolve, is not a constant reason for failure to deploy blockchains throughout a supply chain. Instead, there could be a differing underlying reason which increases the likelihood for an unsuccessful deployment.

As well as technological challenges, the participants also raised several issues which occurred in the external environment to the deployment lead organisation. However, two of these challenges featured more prominently than the others – namely, (1) supply chain

onboarding to the network and (2) the lack of shared vision between network members. In three of the four cases which were at a stage where the supply chain was being onboarded to the network, supply chain onboarding was cited as being a major hurdle which was being faced. In Case 01, there was a reluctance from some supply chain members for a blockchain which would increase security against fraudulent behaviours. Further, the participant explained that the members wanted to know what benefit they will receive from having the blockchain operate in their organisation. This suggests that there is a need for the blockchain deployment to offer value to each stakeholder member that is providing access for the blockchain. Likewise, in the atypical real estate case, Case 04, the interviewee described how they experienced onboarding challenges that stemmed from the supply chain members feeling the blockchain offered them a lack of value. In this Case, due to a lack of value, they had one member choose to leave the network whilst still taking all of the business they attained as a result of the blockchain network. The interview participant continued by explaining how they also faced challenges in accounting for the legislative requirements of each organisation which greatly increased the complexity of the onboarding as there was a lack of standardisation for onboarding. This was because each prospective network member had their own legislative requirements which they were subject to which affected their role specifically. For example, a lender was subject to one set of legislative requirements whilst an estate agent was subject to a different set of legislative requirements. Thus, there was a need to cater to each prospective member which greatly increased complexity and reduced the level standardisation for onboarding members. Further, in the pharmaceutical case, Interview Participant 13 explained how the pilot phase is the most difficult as this is the phase where you attempt to onboard the supply chain to the network whilst developing new ways of collaborative working around the blockchain system. Similar trends can be seen in Case 02. However, Case 02 is unique in that the deployment was led by a consortium of stakeholder organisations. Despite being a part of the deployment from the start, one of the deployment lead organisations pulled out of the project partly due to not seeing a sufficient value from the blockchain solution. Notably, the participant felt this was because they were focused on the blockchains functionality to produce invoices and letters of credit, as opposed to focusing on the value the blockchain could offer them in terms of being part of a supply chain finance solution which could create new revenue streams for the bank.

"And that's exactly what we tried to do to prepare the Bank to think differently, think about different business models, that you could do finance phrases and trigger from their logistics instead of thinking about just an invoice or a letter of credit. Because traditionally trade financing is dying. They should focus more on supply chain finance where [unclear]. But you want to have proof that actually something happens." – Interview Participant 07, Case 02

Thus, supply chain onboarding is a theme which seemingly stems across all of the studied cases, irrespective of if they were typical or atypical. However, the root cause of this issue is more complex. In some instances, a lack of value for the supply chain member was cited as being a hurdle at onboarding. Meanwhile, in the heavily legislated atypical Real Estate Case, Case 04, the onboarding challenges also stemmed from an increased complexity due to the legislative requirements and increased bureaucracy which were present at the different stakeholder organisations. These results suggest that the empirical outcome of supplier onboarding challenges can have numerous underlying causes.

The second external issue which was discussed was a lack of a shared vision. This manifested in several ways unique to each circumstance. In Case 02, lack of a shared vision between the consortium partners was cited frequently. Moreover, it was referenced in a variety of different ways. It was first referenced as an underlying cause of the issues in establishing and funding road map between the consortium members. It was then cited as a cause of friction whereby consortium members would say one thing to the group, but then act in a completely different way. This caused for integrity-based trust to be eroded between the consortium partners which in turn led to a further dealignment and share vision between the consortium members. The interview participant also linked these issues to cultural differences between the member organisations. And finally, the lack of a shared vision for the platform was ultimately the reason why the project ceased when there was disagreements concerning the preferred blockchain platform between the members. In Case 04, there was a lack of shared vision for the network as different members wanted different functionality. As discussed previously, this could be a result of the need for each member to feel they are realising a certain level of individualistic value from the blockchain.

And in Case 05, the interviewee explained how the different agendas of each of the stakeholders of the project was also a point which was causing issues. However, in this case this could be a consequence of the atypical funding strategy of the project as the project was a grant which was won by several organisations. The interviewee discussed the funding approach as disincentivising some organisations from dedicating large resources to the project and thus they had their own motivations, which were not always aligned with the collective objective.

5.4. Summary of findings and discussion

Like Kouhizadeh et al. (2021), this study mostly finds evidence supporting the barriers to blockchain adoption that were identified in the adapted TOE framework first proposed by Saberi et al. (2019). Further, as a consequence of the emergent nature of the methods being applied within this study, a large quantity of findings were discussed throughout this chapter. This included some peripheral findings such as: (1) The indecision and potential switch currently occurring from private permissioned blockchain systems towards public permissioned infrastructure as a consequence of the value which public protocols can offer coupled with the number of developers with competencies working with public protocols; (2) the product, objective, and industry can each drastically impact the complexity of the blockchain system in a variety of different ways; and (3) Technology providers advertising competencies which they do not have in order to secure contracts. However, the remainder of this section will conclude by focusing on two key findings, pertaining first to Research Questions 1 and 2, and how these may be mitigated as part of Research Question 3, each in the context of some of the extant literature and the theoretical framework. The findings in Research Question 2 are presented according to the entities, structures, potentialities, and conditions which form the causal mechanisms that create observable events in the Empirical (Sayer, 1984). The findings of Research Question 3 detail the steps that can be actioned as a means to mitigate some of the conditions and potentialities to reduce the occurrences of the causal mechanism leading to negative events.

Research Question 1: What are the inhibitors to the successful deployment of a blockchain throughout a supply chain?

Research Question 2: How do causal mechanisms cause the inhibitors to the successful deployment of a blockchain throughout a supply chain to occur?

Finding 1: Onboarding supply chain members to the network is the most significant cause of failure when deploying production-grade blockchain solutions throughout a supply chain as a consequence of the causal mechanisms of an incentive-power relational dynamic, competence-based trust, and integrity-based trust.

One significant evolution of the Saberi et al. (2019) TOE template pertains to Inter-organisational Barriers, which have been replaced by Governance Challenges within this study. Governance was the preferred term due to blockchain governance being a common term in the extant blockchain literature to describe the "means of achieving the direction, control, and coordination of stake-holders within the context of a given blockchain project to which they jointly contribute" (Pelt et al., 2021, p21). The most significant finding from this study is the prominence of establishing blockchain governance and onboarding supply chain members to the network as the most critical challenge facing blockchain deployments in supply chains. This is discordant with previous qualitative research that has shown upper management support (Clohessy and Acton, 2019), lack of understanding (van Hoek, 2019), and financial challenges (Treiblmaier et al., 2021); and quantitative research that has evidenced technological scalability (Biswas and Gupta, 2019), lack of understanding (van Hoek, 2019; Treiblmaier et al., 2021), cultural differences between supply chain members (Kouhizadeh et al., 2021), and cost (Nayal et al., 2020) as being the most prominent barriers to blockchain adoption in supply chains; and literature review studies that showed organisational readiness (Clohessy et al., 2020), blockchain immaturity (Duan et al., 2020), and regulatory uncertainty (Yadav et al., 2020), as being the most frequently documented challenges to blockchain deployment throughout a supply chain. This may be explained by: (1) this study capturing the perspective of individuals who have worked on blockchain projects that have progressed beyond a pilot stage. This criterion differentiates this research from the majority of relevant studies and may be evidence that governance becomes a more significant challenge as the blockchain reaches production grade (van Hoek, 2019; Wang et al., 2019; Treiblmaier et al., 2021). This relies on the assumption that onboarding

becomes a more significant challenge as a deployment lead attempts to onboard organisations outside of the key few selected partners that are identified at the investigation, proof-of-concept, and pilot phases. Further research, as blockchain becomes more commonplace and standard in industry, will be needed to test this assumption. (2) As stated by Treiblmaier et al. (2021) blockchain research collects data that reflects the time period of data collection, late 2022-2023, and as a result documents a blockchain environment that is distinct from that when previous relevant interview studies were conducted (eg Clohessy and Acton, 2019; van Hoek, 2019; Wang et al., 2019; Treiblmaier et al., 2021; Ganguly, 2022). Alternatively, this may be a combination of the aforementioned factors and/ or additional considerations.

Consistent with the form of critical realism being applied in this study, it is necessary to understand the underlying causal mechanisms which cause this occurrence to be observed in the data (Easton, 2010). As is presented diagrammatically in Figure 8, this research shows evidence suggesting that onboarding challenges are primarily a consequence of an interrelated twofold dynamic where the presence of either may inhibit the blockchain onboarding process: (1) lack of incentive mechanisms which create value for each supply chain member and (2) the deployment leads lack of power and influence over the supply chain members. This finding is consistent with the predictions of the transaction cost economics theorem which is the basis for the competence-based trust which is incorporated into the TOE theoretical framework in this study (Williamson, 1975, 1979, 1993; Zhong et al., 2017; Connelly et al., 2018). Despite few studies accounting for this construct, this finding conflicts Saurabeh & Dey (2021) who found influence and control to be the least significant factor of those studied in blockchain adoption. Further, many interviewees explained that there is a need for blockchain to create a communal value for each supply chain member, whilst some interviewees stated that the value which is provided must be differentiated according to the role of the network stakeholder.

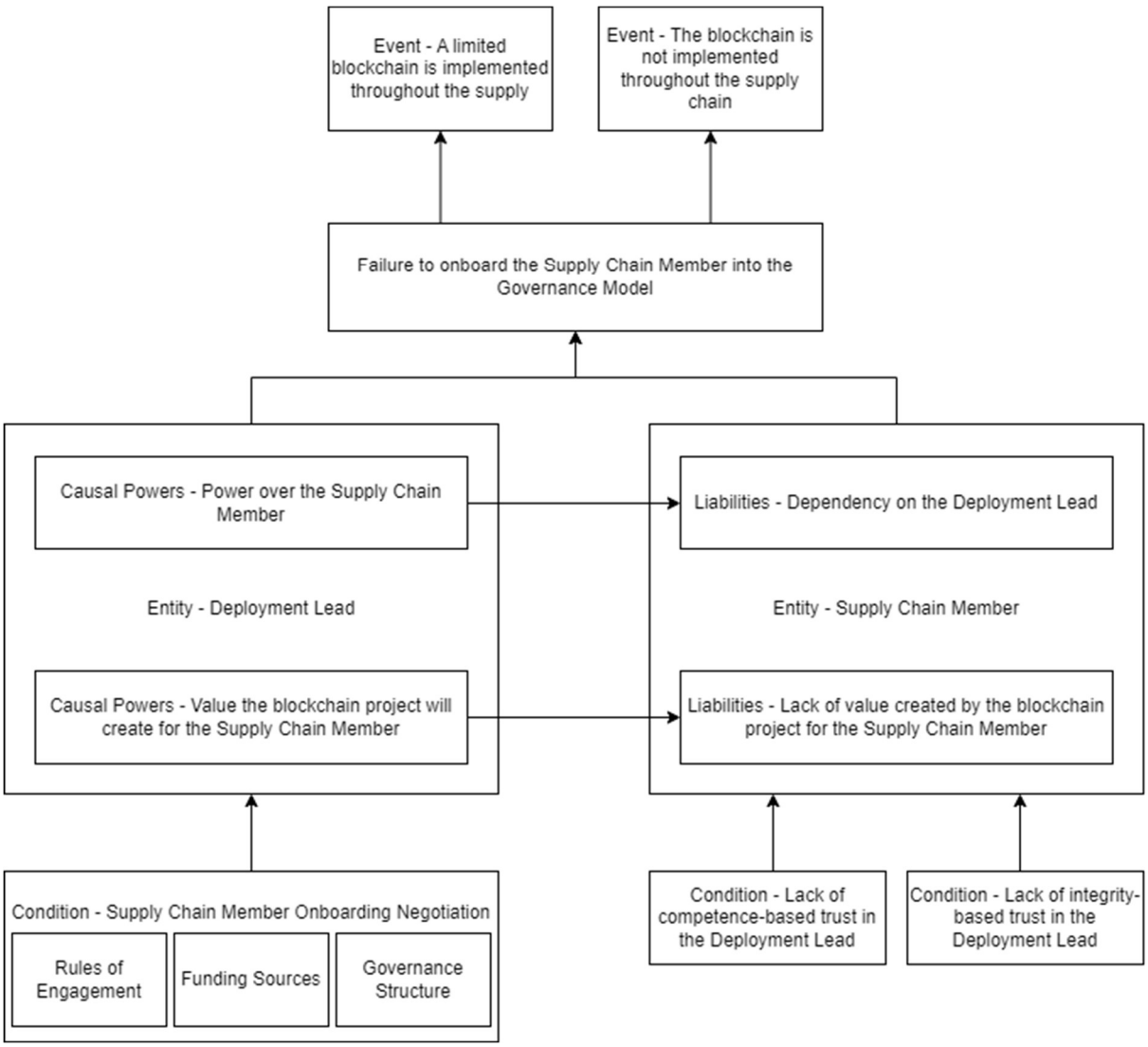

Figure 8: Causal mechanisms that can lead to a failure to onboard supply chain members into the governance model (adapted from Sayer, 2000)

An additional contribution of this research is evidenced in the differentiating between the various phases of blockchain deployment. This approach revealed that some challenges are specifically tied to a certain phase; whereas others are continual throughout the blockchain project. For example, negotiating the governance model with the supply chain members was demonstrated to be a significant issue for deployment leads. Moreover, issues around rules of engagement, funding, and governance structure were 3 subconstructs identified by the interviewees where negotiations may cease. Concordant with the extant research,

interorganisational trust was cited by numerous interviewees as an underlying causal mechanism which could influence each of these negotiation points (Clohessy et al., 2020; Francisco & Swanson, 2018; Hastig & Sodhi, 2020; Yadav et al., 2020). However, by accounting for integrity-based trust and competence-based trust within the theoretical framework, this research extended upon these previous literatures. The interviewees explained how a lack of integrity-based trust can make negotiations more challenging. This is because supply chain members don't trust how their data will be used, supporting the research of Clohessy et al. (2020). Alternatively, competence-based trust can cause supply chain members to feel their data is not sufficiently secure. Value misalignment, a factor included within integrity-based trust in some studies in the interorganisational relationship domain (Poppo et al., 2015; Connelly et al., 2018), was also reported as a condition which can lead to collaboration issues when deploying blockchain solutions; providing qualitative evidence and increasing the specificity of other studies which have shown collaboration challenges in this context (Kouhizadeh et al. 2021; Saberi et al. 2019; Wang et al. 2019). This study evidenced that this can also occur when organisations attempt to redesign their operational practices with their supply chain members, as developing new collaborative business models was evidenced as a point of failure for the deployment, supporting the research of Wang et al. (2019). In this research, the finding of a relationship between power and incentivisation as onboarding strategies is grounded in competence-based trust. The Connelly et al. (2018) competence-based trust that is being applied in this study acknowledges resource-dependence theory and transaction cost economics. Thus, literature suggests that as an organisations resource dependency on another organisation increases, it increases the likelihood that the other organisation will act in a trustworthy way to maintain the relationship (Zhong et al., 2017).

Finding 2: The lack of sufficient value which a blockchain can add to the use case is a point of failure for the deployment of a production-grade blockchain throughout a supply chain as a consequence of the underlying causal mechanisms of the difficulty establishing the value production-grade blockchains can add, lack of a business need, and lack of blockchain competencies.

As shown in Figure 9, the other most notable finding was evidence for the necessity for blockchain to add value being the second most featured code within the study.

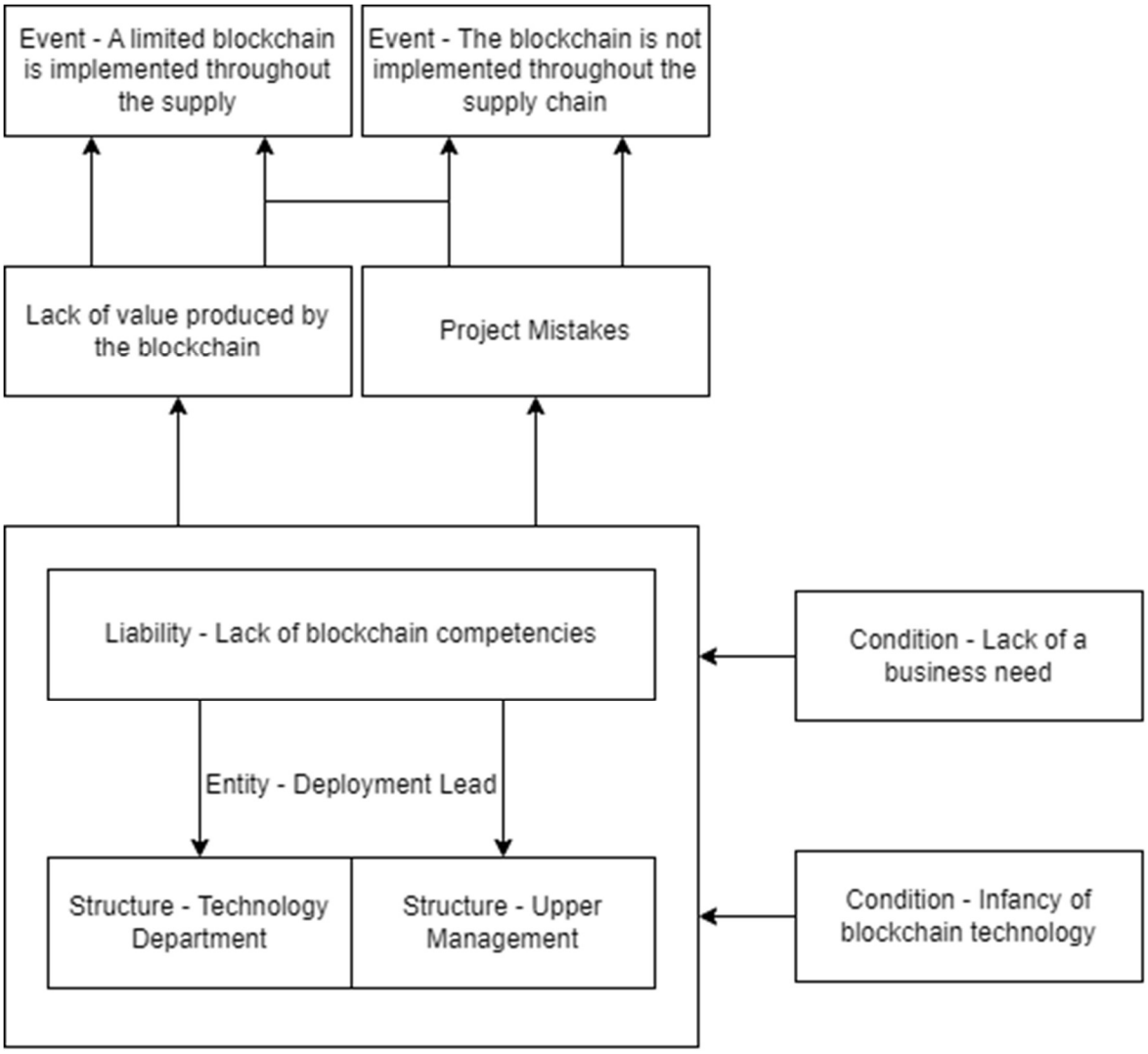

Figure 9: Causal mechanisms that can lead to a lack of value being realised by the blockchain project (adapted from Sayer, 2000)

There was significant consensus between participants that the blockchain technology must address a business need that creates value as when a blockchain project does not address a business need that creates value, numerous participants noted how this was getting involved with blockchain for the wrong reasons.

As stated by Interview Participant 15, lack of understanding of the technology department at the deployment lead organisation are conditions which can cause a lack of value to be produced by the blockchain as limited blockchain competencies inhibit an organisations ability to build a blockchain solution which can elicit sufficient value as they invest in a use-case which does not meet their own requirements. Lack of understanding was also

evidenced within the case interviews as being a cause of organisations wasting money as they make mistakes in regards to the blockchains development. As a result, lack of understanding was cited as being a prominent property of the Deployment Lead organisation which can lead to the blockchain solution being implemented in limited form, or not being implemented. Despite this, some of the interviewees commented that as blockchain technology matures, then so will blockchain competencies within organisations.

Research Question 3: What are the actionable best practices which can be implemented to mitigate the most prominent inhibitors to the successful deployment of a blockchain throughout a supply chain?

Whilst Research Question 2 aimed to understand the causal mechanisms which can inhibit the deployment of a blockchain solution throughout a supply chain, Research Question 3 aims to understand some actionable best practices which can be implemented to address these barriers. Consistent with the Critical Realism being applied in this study, this is achieved by developing solutions which can reduce the impact of the conditions and potentialities which were identified in Research Question 2 (Easton, 2010). Derived from Figures 8 and 9, table 20 outlines the liabilities, causal powers, and conditions which cause the most significant challenges in this study – onboarding Supply Chain Members into the blockchain governance and the lack of value which can be elicited from a production-grade blockchain – alongside some actionable best practices that interviewees detailed, and are discussed in depth in Section 5.2. and Section 5.3., in the context of the identified barrier. As is evidenced in Table 20, the 7 causal powers, liabilities, and conditions are (1) Deployment Leads lack of power over Supply Chain Member, (2) Deployment Lead offering a lack of incentives for the Supply Chain Member to join the network, (3) Lack of blockchain competencies, (4) Lack of integrity-based/ competence-based trust, (5) Negotiation to onboard supply chain members to the network, (6) lack of a business need to join the network, and (7) infancy of blockchain technology. The remainder of this summary will provide a brief overview of some of the identified best practices which can mitigate the impact of the conditions, causal powers, and liabilities, according to the findings and discussion presented in Section 5.2 and 5.3.

Table 20: Table showing the underlying conditions and potentialities alongside actionable best practices which can mitigate these issues according to the interview data

Conditions, causal powers, and liabilities	**Actionable best practices which can mitigate the impact of the conditions, causal powers, and liabilities**	**Reference**
Lack of power over supply chain member	Use incentivisation as an onboarding strategy by offering: (a) Risk Incentives • Real time data assurance • Bi-lateral open-book data disclosure (b) Financial Incentives: • Loans at more favourable rates • Price increase • Improved accounts receivable • Reduce costs • Increased publicity	Table 16, Section 5.2.1.1.
Lack of incentives for the supply chain member to join the blockchain governance	Use power as an onboarding strategy when: • Supplier has a weaker financial position • Supplier has high dependence on the buyer	Table 16, Section 5.2.1.1.
Lack of blockchain competencies	Means of accounting for blockchain competencies: • Limited scale blockchain projects to build blockchain competencies • Outsourcing the blockchain project to a technology provider • Build an in-house blockchain centre of excellence	Section 5.2.2.2.

Lack of integrity-based/ competence-based trust	Means of mitigating challenges associated with a lack of trust: (a) Develop a roadmap for the blockchain project in accordance with several principles: • Adapt the roadmap to the Supply Chain Members needs • Continual evaluation of the roadmap • Involve critical stakeholders in roadmap design • Develop a hierarchical list of stakeholders • Plan roadmap according to the 'path of least resistance' (b) Neutral 3rd party to arbiter the network governance (c) Establish a separate legal entity with representatives from critical stakeholders	Section 5.2.1.3.
Negotiation to onboard the supply chain member to join the blockchain governance	(a) Members • Behaviours • Sanctions • Data • Funding • Infrastructure (b) Administrators • The same points as are discussed for members • Permissions • Add/ Remove members	Table 17, Section 5.2.1.2
Lack of a business need for... blockchain technology	Conditions where blockchain may add value: • Safety critical supply chains • Unbanked supply chains • Lack of integrity-based trust or competence-based trust • Industries where litigation threat is high	Table 18, Section 5.2.2.1.

	• Industries where fraud is prevalent • Regulatory compliance • ECG reporting • Paper based processes	
Infancy of blockchain technology	The infancy of blockchain technology is a condition which cannot be directly addressed. However, the discussion around lack of understanding in Section 5.2.2.2. may offer some means to mitigate this: • Limited scale blockchain projects to build blockchain competencies • Outsourcing the blockchain project to a technology provider • Build an in-house blockchain centre of excellence	5.2.2.2.

Lack of power over the Supply Chain Member was identified as a causal power of failure to onboard supply chain members to the network. In this instance, the interviewees recommended onboarding Supply Chain Members to the network through incentivisation. Two types of incentives were discussed – risk incentives and financial incentives. Offering a risk incentive is a means of providing value to the Supply Chain Member by reducing uncertainty and unpredictability throughout the network. These approaches are appropriate when the operating in a safety critical supply chain or when there is a lack of trust in the Deployment Lead by the Supply Chain Member. Financial incentives are when the Deployment Lead offers the supply chain member a greater value if they join the network. This included factors such as, improved accounts receivable, paying a higher price for the product etc. These approaches are appropriate when the Supply Chain Member has a poor cash to cash cycle, or if factors such as fraudulent goods diminish the price that is currently paid for the product.

Lack of incentives was also identified as a causal power for failure to onboard supply chain members to the network. If this is because the Deployment Lead is unwilling or unable to offer an incentive for the Supply Chain Member to join the network, and onboarding through power strategy may be more suitable. For this to be possible, there needs to be a power asymmetry between the Deployment Lead and the Supply Chain Members. This may occur when the Supply Chain Member has a weaker financial position, or when there is a high dependence of from the supply chain member on the deployment lead. Consistent with the theoretical framework being applied in this study, dependency may me a consequence of asset specificity or where the Deployment Lead is responsible for a large quantity of the Supply Chain Members business.

Lack of blockchain competencies was discussed as a liability of the Deployment Lead entity that could lead to a lack of return on investment from the project. In these circumstances, several interviews made recommendations which could be implemented to either build internal blockchain competencies or leverage external blockchain capabilities. This could involve hiring Technology Providers and consultants with the required blockchain expertise to build the blockchain network and advise on operational restructuring to elicit value from the project. Alternatively, this may be in the form of Deployment Leads trailing many small, inexpensive, blockchain projects as a means of building internal expertise in blockchain. Some interviewees discussed examples of organisations strengthening internal blockchain competencies by establishing a 'Blockchain centre for excellence' whereby a combination of the aforementioned strategies were implemented alongside expanding the IT department as a means of becoming an industry leader in blockchain technology.

Lack of integrity-based trust and competence-based trust were also cited as conditions that could lead to the failure to onboard a supply chain member to the network. In these instances, 3 non-exclusive types of approaches were detailed which may alleviate challenges. Firstly, a significant quantity of the interviewees expressed the need to develop a project roadmap with a few key stakeholders which are critical to the success of the project. This involves involving the stakeholders in the decision making so the solution offers supply chain value, whilst also recognising their needs so that they are invested in the project. Secondly, one interviewee explained how he worked on a case whereby as a means of mitigating the concerns of supply chain members that their data would be used

opportunistically, a neutral 3rd party was brought in to arbiter the blockchain governance and to maintain the network long term. Thus, the Deployment Lead would forego some degree of power over the network making it more equitable to participants. Lastly, another participant cited his main regret in their unsuccessfully implemented blockchain project was that they didn't establish a separate legal entity with representatives from all of the key collaborating firms. He explained how this could have prevented each organisation from acting as separate entities with their own selfish interests, and would have made a more communal project that seeks value for each member.

Negotiations to onboard supply chain members was identified as the second phase of onboarding supply chain members into the governance. According to the experiences of the interviewees, this research has outlined 6 different topics which must each be negotiated and agreed upon, as well as differentiating these discussion points according to the role that the supply chain member would have in the network. This involves discussions concerning (1) behaviours, (2) sanctions, (3) data, (4) funding, (5) infrastructure, and (6) permissions. It is recommended that each of these points are discussed in order to establish how the supply chain member will engage with the blockchain governance if they were to join and who would have access to their data.

Lack of a business need was an underlying condition that was cited by many interviewees as a reason why blockchain projects failed to offer sufficient return on investment to the Deployment Lead or the supply chain. Lack of a business need was also discussed in the context of marketing as several organisations engaged with blockchain projects as a means of wanting to advertise that they are using blockchain. As a result, across the interview data, many interviewees explained which use-cases they feel blockchain inherently offers value to the supply chain use case. This included factors such as safety critical supply chains, supply chains with high levels of fraud, and supply chains where regulatory compliance is complex.

Lastly, the infancy of blockchain technology was cited as an underlying condition which inhibits the level of value which can be realised through deployment of a blockchain throughout a supply chain. Whilst this is a condition which cannot be directly tackled outside of waiting for blockchain technology advancements, it may be reasonable to assume that employing the best practices which account for a lack of blockchain understanding, may mitigate some of the challenges associated with the infancy of the technology. However,

due to the non-iterative data collection and data analysis processes employed within this study, no data was collected on means of mitigating the infancy of blockchain technology.

6. Conclusion

This study aimed to understand the reasons why blockchain technology can be unsuccessfully deployed throughout a supply chain by investigating the main obstacles which impede this process, from a variety of key stakeholder perspectives, through an adapted version of the TOE theoretical framework. A set of barriers to production-grade blockchain deployments was identified. Through the frames of meaning of the interview participants, the data was analysed to detail the underlying causal mechanisms which when activated can lead to the most prominent reasons for failure to deploy a production-grade blockchain solution – (1) failure to onboard a supply chain member into the governance and (2) lack of return on investment from the blockchain project. Once the underlying causal mechanisms to the most prominent barriers were identified, the data was analysed to understand what best practices the interviewees had discussed that when actioned, could mitigate the impact of the underlying causal mechanisms. From this, a framework was established, in the form of a series of tables (Table 16, Table 17, Table 18, Table 19, Table 20), that can be used by industry personnel to minimise the impact of the causal mechanisms of the most prominent barriers to the deployment of a production-grade blockchain throughout a supply chain.

6.1. Industry Implications

As was detailed throughout the methodology, the emergent nature of this research meant that many findings were made throughout this study; most of which cannot be covered in detail outside of the discussion chapter. Thus, consistent with the Section 5.4. Summary of findings and discussion, the remainder of this paper will only consider the most notable

findings from this research. The managerial recommendations are primarily derived from the best practices detailed in Research Question 3, which address the identified barriers to blockchain adoption throughout a supply chain which were particularised in Research Question 2. Accounting for Research Objective 1, efforts are made to consider the phase of blockchain deployment where the barrier may occur and where best practices can be implemented. The project phases alongside their corresponding objectives was detailed in Table 19. Further, as a consequence of the form of critical realism being applied in this study, recommendations for industry are pitched at the underlying conditions and potentialities that form the causal mechanisms which can lead to the barriers that were found in this study occurring.

In order to mitigate the potentialities and conditions found in this research, managers need to plan how they will approach onboarding supply chain members. A roadmap is one identified tool which may help them achieve this. The roadmap needs to differentiate between stakeholders in terms of their criticality to the project and many interviewees reasoned that this should be a collaborative effort between the deployment lead and key stakeholders. The roadmap needs to establish if a power or incentivisation approach is the most appropriate for onboarding. Alternatively, a combination of these approaches may be used in accordance with the criticality of the stakeholder to the project. A roadmap was discussed as a means of minimising the impact of a lack of integrity-based trust or competence-based trust. However, consideration should also be made to hiring a neutral 3rd party that is agreed upon by the deployment lead and the key stakeholders, to enact as an arbiter for the blockchain governance. Alternatively, establishing a separate legal entity with representatives from each of the select key stakeholders may alleviate contentions around trust as the objectives of the collective should be considered central to the project. Lastly, when negotiating onboarding with the supply chain member, the deployment lead should discuss each of the points detailed in Table 17, to ensure that the supply chain member understands their role within the network, what is expected of them to contribute to the network, and how their data will be used within the network.

The second most prominent barrier to blockchain adoption was that blockchain deployments do not realise the expected value. As can be evidenced in Figure 9, this was underpinned by (1) lack of a business need, (2) lack of blockchain competencies, and (3)

infancy of blockchain technology. Thus, there needs to be a business need which the blockchain is addressing in order to add value to the deployment lead and the supply chain members. As is evidenced in Table 18, numerous criteria were identified that can be used by managers to assess the suitability of blockchain technology toward their specific use case. Managers should also look to evaluate the methods that they can employ to attain blockchain competencies within their organisations. This may involve building small scale, private blockchain proof-of-concepts; hiring external technology providers to build a blockchain solution; hiring consultants to reengineer business processes and operations to develop new ways of working that can elicit value from the blockchain system; or building a 'blockchain centre for excellence' where a combination of the aforementioned approaches are utilised in conjunction in order to develop internal blockchain competencies and to become an industry leader in blockchain technology applications. These approaches may also be sufficient in mitigating technological issues that are resultant of the infancy of blockchain technology, whilst better positioning the deployment lead to take advantage of blockchain developments.

Numerous interviewees also expressed that public permissioned blockchains may elicit more value than the their more abundant private permissioned counterparts. Whilst determining an answer to this was outside of the scope of this research project, managers should carefully value the advantages and disadvantages of each system as part of their long-term technology strategies.

This study has also found evidence showing that the complexity of the blockchain solution is tied to the objective of the blockchain project, the type of product that is being tracked throughout the supply chain, and the industry which the blockchain is operating in. As a result, managers should look to understand how their specific use case will impact the value that can be attained from the blockchain and how the complexity will impact the roadmap and the financing of the project.

Lastly, numerous interviewees cited cases of blockchain Technology Providers advertising competencies which they do not have. This finding is especially prominent given that in Figure 9, 'lack of blockchain competencies' was a property of the deployment lead entity in a causal mechanism that could lead to a lack of value being elicited from the blockchain project and that bringing in a technology provider was discussed as a potential solution to

mitigate issues surrounding blockchain understanding at the deployment lead organisation. In one of the case interviews, one of the interviewed Technology Providers also admitted to pushing a specific technology onto the project because they wanted to improve their own competencies with that technology – not because it was necessarily the best suited to the project. As a result, managers should perform their due diligence in assessing any Technology Provider they consider bringing in to the project and where possible it may be recommended that they get the opinions of numerous technology providers and blockchain consultants so that they can cross-evaluate their motives, competencies, and approaches before committing to working with one technology provider on the project.

6.2. Theoretical implications and future research

This study extended upon the qualitative research that sought to understand the barriers that organisations face when trying to establish a supply chain based blockchain system and some novel best practices which can be employed to mitigate the most critical identified challenges (Clohessy & Acton, 2019; Treiblmaier et al., 2021; van Hoek, 2019). This was achieved through the lens of a modified version of the Saberi et al. (2019) Technology-Organisation-Environment theoretical framework for blockchain deployments by differentiating between integrity-based trust and competence-based trust. The TOE framework is one of the most frequently researched theories in the context of supply chain blockchain deployments (Clohessy & Acton, 2019; Ganguly, 2022; Kouhizadeh et al., 2021; Treiblmaier et al., 2021). However, this study differentiated itself from the extant literature in 5 main ways: (1) The adapted TOE framework was applied as an *a priori* starting point to interpret the collected evidence, meaning that inter-organisational barriers were considered which were not a part of other qualitative studies which employed the TOE theoretical framework to understand blockchain deployments throughout a supply chain (Clohessy and Acton, 2019; Ganguly, 2022). (2) Retroductive and abductive inferencing were implemented in conjunction to understand the conditions which lead to events being observed in the empirical and to analyse data which was outside of the initial theoretical framework. As a result of the aforementioned practices, this research extended upon proceeding research by

differentiating between integrity-based trust and competence-based trust as a consequence of interviewees explaining examples of how the absence of each type of trust can have different ramifications in a blockchain context. (3) This research was designed as a response to Treiblmaier et al. (2021) who called for future research that accounts for a variety of key stakeholder perspectives. (4) The strict participation criteriology required that all participants had experience working on blockchain deployments, with a majority of interviewees being involved with projects that have progressed beyond pilot-grade deployments to production-grade deployments. (5) Lastly, this interview study facilitated the collection of emergent evidence through the frames of meaning of the participants, which is in contrast to more frequently published survey research on the supply chain use-case of blockchain technology (Biswas & Gupta, 2019; Wamba et al., 2020; Kamble et al., 2019; Kouhizadeh et al., 2021; Nayal et al., 2021.; Queiroz & Wamba, 2019; Treiblmaier et al., 2021; Wong et al., 2020a; Wong et al., 2020b).

This research makes several theoretical contributions to the blockchain adoption in supply chain literary body. Firstly, this study has found that governance challenges are the most prominent issues facing Deployment Leads as they seek to deploy a blockchain system throughout their supply chain. Specifically, off-chain governance challenges that occur when attempting to onboard supply chain members into the blockchain governance. This finding is discordant with the majority of the extant literature (Biswas & Gupta, 2019; Clohessy & Acton, 2019a; Clohessy et al., 2020; Duan et al., 2020; Nayal et al., 2021; Saberi et al., 2019; Surendra Yadav et al., 2020; Treiblmaier, Rejeb, et al., 2021; Van Hoek, 2019). This may be a consequence of this research capturing an infrequently documented dataset of production-grade blockchain projects. This is significant as the interviewees, within the case study research of van Hoek (2019), stated that as the scope of the deployment increases, the challenges which are experienced change. Thus, as proof-of-concept and pilot grade implementations operate with a smaller subset of stakeholders than production-grade deployments, future research is needed that focuses on production-grade blockchain deployments. As a result, future quantitative research is needed that can empirically test the validity of this finding from a large sample of participants with experience working on production-grade blockchain projects in supply chains. This research also extended upon this result by finding that onboarding supply chain members into the governance was an

outcome that stemmed from two potentialities under three different conditions: (1) lack of value offered to the supply chain members to join the network; (2) the deployment leads lack of power over the supply chain members; under the conditions of (1) lack of integrity-based trust between the supply chain member and the deployment lead; (2) lack of competence-based trust between the supply chain member and the deployment lead; and (3) the negotiation phase of onboarding the supply chain member into the governance whereby the supply chain members roles with regard to funding, rules of engagement, and governance structure are discussed. This research also extended upon the limited number of papers that study blockchain technology deployments with the aim of making recommendations about how best to deploy a blockchain solution (Treiblmaier et al., 2021). In doing this, to address onboarding challenges, this research produced a series of tabulations (Table 16, Table 17, Table 18, Table 19, Table 20) that form a framework that can be used to aid deployment leads with onboarding supply chain members to the blockchain governance that accounts for the various stages of the onboarding process. This is a response to Treiblmaier et al. (2021) calling for future research to produce tabulations and checklists that can aid managers. To extend this finding, future longitudinal case study research is needed that documents the process of a deployment lead organisation onboarding supply chain members to the network.

This research also revealed that blockchain deployments are often hindered by challenges concerning the value that can be elicited from a blockchain deployment throughout a supply chain. This study found that (1) blockchain deployments throughout supply chains do not always add as much value as is intended, (2) organisations find it difficult to establish the expected return on investment from the project, and (3) sometimes the value that can be offered by blockchain is not realised within the budget period. Further, this research also found that lack of a return on investment from the blockchain solution was underpinned by the liability, lack of blockchain competencies, under the conditions of lack of a business need and infancy of the technology. As a result, actionable recommendations were made that can be implemented in order to mitigate challenges associated with eliciting a sufficient return on investment from the blockchain project.

6.3. Limitations

This research was limited in several ways. Most significantly, at the start of this study I had little experience with conducting academic interviews. As was detailed in Section 4.2.1, I conducted a series of pilot interviews as a means of developing my interview skills prior to data collection. Despite this, as is documented in the reflective memo writing following each interview (Appendix E), I felt more comfortable as I conducted more interviews. I also made practical changes to how I was conducting the interviews to account for issues I had in previous interviews; such as refining my interview schedule so it was more readable at a glance. Thus, in earlier interviews I feel I was less capable of asking specific prompts, or circling the conversation back to a note I made earlier. As a result, I believe my later interviews were conducted at a higher level than my earlier ones. This may be reflected in the quality of data that was attained as better probing questions may have been asked in the later interviews. Consequently, there may be inconsistencies between factors such as, the quality of probes used and the interview topic management, throughout the interviews as a result of my development as an interviewer throughout this process.

This research also made a theoretical contribution in that it captured the perspectives of three different stakeholder groups – (1) deployment lead, (2) supply chain member, (3) technology provider/ advisor - to the deployment of a blockchain solution throughout a supply chain. However, supply chain members were identified as another valuable stakeholder group to be interviewed. Despite this, no supply chain members were interviewed throughout this process. Future research should account for this limitation by trying to document this perspective.

This research was also subject to practical limitations with data collection. For example, some of the interviewees were able to dedicate several hours to this project in order to cover all of the identified topics, as well as topics outside of the intended scope of the research. Alternatively, some interviewees were only able to allot half an hour to be interviewed as part of the project. As a result, some of the interviews vary in length to a substantial degree. One consequence of this, that is evidenced within the reflexive memo writing (Appendix E), is that in some of the shorter interviews, a smaller subset of questions

were asked. Thus, some of the interviews omitted questions which were included in other interviews. One example is how with Interview Participant 13, questions were focused on research question 1 and 2 in a greater level of depth, as opposed to attaining a more superficial level of depth about all three research questions.

One limitation of this research is that it was deliberately broad in the type of blockchains which were selected for study. This decision was to enable insight into how different blockchain types may, or may not, elicit different challenges when attempting to deploy them throughout a supply chain. This was a consequence of the literature review as numerous scholars, such as Kouhizadeh et al. (2021), van Hoek (2019), and Zhao et al. (2019), found evidence to suggest this finding. Accounting for numerous blockchain types also allowed this research to extend upon previous studies which focused on one specific function (Clohessy et al., 2020). This research may be considered limited in that it does not have a great enough focus on one specific type of blockchain to enable statistical generalisation. Despite this, framing the research in this way, when coupled with the case selection criteria, enabled insight into how type of blockchain may impact deployment challenges. The findings in this study suggested that whilst the type of blockchain can present different challenges, that this is superseded by more significant considerations such as the value that is generated by the blockchain. Thus, the rationale for studying cases with a broader blockchain type was valuable as it highlighted that this is less of a consideration than other factors. However, as statistical generalisation was not the objective of this methodology, this finding would be better supported if proven in a larger scale quantitative study that focuses specifically on the different types of blockchain. Additionally, in this study blockchain type pertained to the objective of the blockchain – eg track and trace. One limitation of this is that research that goes one step deeper to differentiate between specific blockchain functions may elicit different results. However, this was considered outside of the scope of this research.

This research was also significantly impacted by Covid-19. Full details on the impact of that the coronavirus pandemic had on this research are detailed in Appendix B.

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Appendix

Appendix A – Example review of a journal article (Kouhizadeh et al., 2021) using the adapted template of Salehudin et al. (2017)

Author's Name	Kouhizadeh, M Saberi, S Sarkis, J	Purpose	
(A) Paper Reference (APA)	Kouhizadeh et al. (2021)		
(B) Basic Research Question	1. Why has blockchain technology not been considerably implemented in supply chains for sustainability purposes? 2. Can the barriers be examined theoretically and placed within TOE and force field frameworks? 3. What are the levels of importance and relationships amongst the barriers? 4. Is there potential for sequencing and overcoming these barriers to accelerate blockchain implementation? 5. How do two study groups – scholars and practitioners – perceive the importance and relationships among the barriers? What are the similarities and differences in their perspectives?		
(C) Related Key Papers	1. Saberi et al. 2019b 2. Hoek (2019) 3. Karamchandani et al. 2019 4. Azzi et al. 2019		
(D) Motivation for the research (Intro)	Blockchain is a disruptive technology which is currently very hyped due to potential benefits the technology can offer to industry. Supply chains are becoming increasingly complex		

	and blockchain can be a solution to this complexity. However, this begs the question, what barriers impede the adoption of this technology in SCM. Further, how are these barriers connected and how do they impact each other?
THREE Key Questions of any Empirical Research Project	
(E) Idea (Aims and Objectives/ Research Hypothesis)	"to examine the barriers that impede blockchain adoption for integrating sustainability in the supply chains; with theoretical observations that form research propositions to advance key theories in the supply chain management context. The present study also seeks to examine how supply chain academics and practitioners perceive barriers." (p4)
(F) Data (Type, Size, Source etc)	Used a convenience sample of academics and practitioners due to the novelty of the domain. 35 participants from academia and 12 from industry. Academics had on average 14 years experience and practitioners had on average 19 years experience. Most practitioners were in consulting and leadership positions. Most academics were mostly Professors.
(G) Tools (Data analysis method)	Decision Making Trial and Evaluation Laboratory – DEMATEL ("DEMATEL evaluates the complex interrelationships among variables and factors, classifies them into cause and effect clusters, and provides a hierarchical structure for effective solutions (Yang et al., 2008)" p7) Uses TOE and force field theory as a lens to conduct analysis through.
TWO Reasons Why	
(H) What's New (Why is this paper different? What's it doing that is new? Idea, data, tools etc)	1. Investigates the differences in perceptions of academics and practitioners. 2. Extends on quantitative literature that used SEM and other regression analysis by employing DEMATEL, which is (supposedly) more statistically sound in

	describing causation, to understand blockchain adoption in supply chain management.
(I) So what? (Impact on stakeholders)	Intended Contributions 1. Understanding the barriers that impede blockchain adoption for sustainable supply chain management and evaluating their interrelationships 2. Using theory to further explain the barriers of blockchain technology adoption for sustainable supply chain management while extending theoretical underpinning to barriers analysis of organizational innovation adoption 3. Evaluating differences and similarities of barrier perceptions amongst two research stakeholder communities – academics and practitioners 4. Providing insights into how DEMATEL methodology can be used for theory extension and development by informing causal relations for research Proposition development
ONE Bottom Line	
(J) Contribution (What is the research implication of the paper and what further questions can be asked of the study?)	Following their analysis, the authors conclude by providing 6 propositions that aid in the explanation of blockchain adoption in sustainable supply chain management. 1. "Stakeholder theory can expand the usability and understanding of the TOE framework. Different stakeholders will perceive underlying factors differently especially in emergent and complex techno-logical and organizational relationship" 2. "Organizational barriers mediate the relationship between technological barriers and supply chain barriers in blockchain adoption for sustainable supply chain management"

	3. "Blockchain and SSCM accessibility is reduced through maturity and security concerns within the technology TOE dimension. Lack of accessibility reduces blockchain in SSCM adoption" 4. "Blockchain adoption in supply chains requires tangible and intangible resources. However, intangible resources play a more important role in successful adoption" 5. "Blockchain adoption for sustainable supply chains will positively relate to relational rents and serve as motivation to decrease supply chain barriers. Relational rents are influenced by building sustainability- based relation-specific assets, improved knowledge sharing routines, building complementary sustainable supply chain resources, and embedding effective sustainability governance structures" 6. "In the blockchain technology setting, when companies integrate blockchain in their supply chains, coercive and normative pressures can affect mimetic forces; to overcome resistant forces to adoption of blockchain in SSCM"
(K) Other Consideration	Key Findings: 1. The authors found that the academics and practitioners viewed supply chain barriers and technological barriers as the most prominent barriers to blockchain adoption in SSCM. 2. The authors also found that technological barriers and external barriers need to be addressed prior to supply chain barriers as these impact on supply chain barriers. 3. Tech barriers must be addressed first, as tech barriers being addressed is expected to address supply chain barriers. In this

	view, the solutions to the technological barriers would be expected to solve some of the supply chain barriers. 4. The authors observed several divergences in responses between the academics and the practitioners. Analysis of the practitioners shows tech challenges to be most prominent whilst academics believed supply chain barriers were more prominent. This suggests the practitioners are more technology orientated. Practitioners believed that tech, external, and organisational barriers influence SC issues whilst academics believed that organisational barriers are less significant. One other difference was that practitioners viewed access to technology as a barrier whilst academics did not. The immaturity of the technology was cited as a barrier to implementation amongst academics and practitioners.
(L) Limitations	1. 2.
(M)Quotes	1. "The novelty of blockchain technology and a scarcity in actual SSCM blockchain implementation limit a broad-based study" pp7-8 2.

Appendix B – The University of Sheffield: Covid-19 Impact Form

STUDENT'S DETAILS	
Name: Matthew Hinchliffe	Registration Number: 180325218
Department: Management School	Faculty: Social Sciences
Please provide a brief summary of the work you were planning to complete before covid-19 restrictions were implemented (max 300 words)	

This PhD was originally a 4-year funded collaborative PhD between The University of Sheffield and A*STAR Singapore Institute of Technology and Manufacturing. Years 1 and 4 were in Sheffield and 2 and 3 were in Singapore. In year 1 I would do my confirmation review and a thorough literature review of open-book accounting and blockchain. Year 2 and 3 would be for data collection. This would have been in the form of case-based data which would be collected in Singapore, using the relevant blockchain connections and blockchain projects that A*STAR were involved in as a technical university with extensive blockchain competencies. My supervisor had also held talks with a Vietnamese company (including flying out to discuss the project) who were considering deploying a blockchain throughout their supply chain, that may have been one of the documented cases within this research.

As was detailed in my Confirmation Review prior to Covid-19, "the intended contribution of this research is [was] to produce an analytically generalisable theorem that explains how blockchain-based data disclosure using an open-book accounting system can be managed as a consequence of interorganisational social factors". Thus, the original focus was on open-book accounting, and trying to understand how organisations could operate when using a blockchain system to facilitate the bilateral or unilateral data disclosure. This was a niche use case of blockchain technology that was very dependent on access to organisations that were invested in this use case. However, when my funding source was

changed to remove A*STAR from my PhD as a result of Covid-19, I was unable to access any of the intended data.

Please provide a summary of plans for specific studies you were intending to conduct in the future (see note 1) (max 300 words)

Intended Research

- I had planned to collect data through A*STAR Singapore Institute of Manufacturing and Technology who were funding my PhD. Data collection was to be in Singapore. A*STAR had numerous blockchain projects which they were working on, and the plan was that the value A*STAR would add to this collaborative PhD was to provide access to cases which would form part of a case study research.
- I had also planned to collect data from farmers in Vietnam as there was talks to establish a blockchain system in Vietnam. Before Covid-19, my supervisor had flown out to Vietnam to discuss this further. This was planned to be one of the longitudinal case studies that would be documented in this research. However, when Covid-19 happened I had to redesign my research so it could be conducted remotely which meant that a longitudinal case study featuring observations wasn't feasible. Further, my understanding is that Covid-19 also meant that this project never happened.

Adjusted Research

- I redesigned my research so that it was an interview study as opposed to a case study as I no longer had access to a case. An interview study was considered more accessible for data collection.
- I had to expand/ change my research. Originally, I was looking at blockchain-based open-book accounting. However, this was a niche use case. Thus, I changed to blockchain-based supply chains as this was a more common use case and data would be more available. This had huge ramifications as supply chains and cost

accounting are different research areas and this meant all of my previous work was no longer directly valuable towards the thesis.
Where relevant, please provide details of changes to your personal circumstances (see note 2) (max 150 words)
My issue was that my personal circumstances didn't change as was expected. This meant I didn't have access to the cases I was intending on studying. I lost a significant amount of time where I still thought I was going to be moving to Singapore. I was intended to start in Singapore in July 2020. However, in July 2021 I was still in the UK, I still expected to go to Singapore and I still had the same research plans, but my 2-years funded in Sheffield was about to expire. Thankfully, Sheffield University switched me onto a 3.5-year PhD with no Singapore connection. However, this meant I lost 6-months funding from my PhD and 12 months of time waiting to move to Singapore. Thus, I had to redesign my research, collect data, analyse data, and write a new thesis on a different topic, and I was 24-months into my PhD.
If your thesis includes Covid-related research, please include a brief statement of how it relates to your overall research aims (see note 3) (max 150 words)
n/a
Please provide details of any previous funded extension, tuition-free extension or non-medical Covid-related leave of absence approved since March 2020
n/a

Appendix C - General Interview Schedule

Introduction

1) Hi, Nice to meet you
    a. **[Interviewee Name]**
        i. I appreciate you **taking the time** to do this interview
    b. Scheduled **an hour**, should be enough time but can I just ask are you flexible or do you need to go at…
2) Introduce me
    a. I'm Matthew
        i. PhD researcher and I am a student **lecturer at UoS**
            1. Mainly lecturing master's students
                a. **Management accounting, strategic management, and supply chain technology**
                b. Emphasize technology
3) Introduce my PhD research
    a. I am looking into how to **implement and scale blockchain** systems in supply chains
        i. I am looking at barriers/ challenges, solutions, resources, and other contextual factors
    b. I am doing this by **interviewing people** who have **first-hand industry experience** working with blockchain technology, and have been part of the implementation, scaling, or establishment, or a blockchain project.
    c. I am not 100% certain what format I want to **present the findings**/ results in, whether it be a framework, or some form of tool which can be used to aid organisations in implementing and/ or scaling their blockchain solution
4) Setting expectations
    a. **Non-technical** paper
        i. Business student, not a software engineer student
    b. Focus is on **enterprise blockchains**

i. Not on public DeFi networks

c. Emphasis on **DLTs that are implemented in a supply chain** setting in that they are used and interacted with by several organisations
    i. Where preferable
    ii. Is that something which you have experience with?

d. I know we spoke over email about being **non-specific to your customers**, if at any point you feel a question is too close to a specific customer then please just say and I can **redirect the question**.
    i. Like I said in the email, you do not need to mention any specific company by name – however, some **level of description** such as industry, objective of the DLT, or the scope of the DLT, etc, could provide some very useful context.
        1. I am trying to gage how various **contextual factors** can impact these barriers and the available solutions.
    ii. Only share what you are comfortable sharing

e. During the interview you may see my typing,
    i. I am just **taking notes**

f. Any questions?

5) START THE RECORDING

a. **MH, [Interviewee Name], [Time of Interview], [Date of Interview]**

Open

1) **Background information** and your **experience**
    a. Time working with blockchain
        i.
    b. Role
        i.
2) **Types of blockchain projects** that you have worked on

a. **objective** of different DLTs (tracking, leasing, etc), **scopes** of the projects, **accompanying technologies** etc
    i.
b. Sector and solution types
    i.

Body

1) **series of phases** (Experiential)
    a. Research, POC, Pilot, Scaling
        i.
2) **Most frequent challenges** which blockchain projects in supply chains generally run into when implementing and/ or scaling? (Knowledge)
    a. Organisational
        i. Financial constraints, management support, understanding of DLT/ ease of use, stakeholders, existing IT department/ resources, unknown ROI
            1.
            2.
            3.
    b. Technological
        i. Data collection issues, hardware/ software issues, immutability challenges, integration issues, scalability issues, security issues, sustainability/ energy
            1.
            2.
            3.
    c. Supply Chain/ External
        i. Governmental policy, lack of industry examples, market competition, challenges onboarding supply chain, Collaboratory challenges, cultural difference, data and information transparency issues
            1.
            2.

3.

3) **Most derailing** issues? Projects getting **scrapped** or **severely disrupting** the process. (Knowledge)
    a. Organisational
        i. Financial constraints, management support, understanding of DLT/ ease of use, stakeholders, existing IT department/ resources, unknown ROI
            1.
            2.
    b. Technological
        i. Data collection issues, hardware/ software issues, immutability challenges, integration issues, scalability issues, security issues, sustainability/ energy
            1.
    c. Supply Chain/ External
        i. Governmental policy, lack of industry examples, market competition, challenges onboarding supply chain, Collaboratory challenges, cultural difference, data and information transparency issues
            1.
4) **Any other problems** which you encountered? why are these important? (Experiential/ Knowledge)
    a. Organisational
        i. Financial constraints, management support, understanding of DLT/ ease of use, stakeholders, existing IT department/ resources, unknown ROI
            1.
    b. Technological
        i. Data collection issues, hardware/ software issues, immutability challenges, integration issues, scalability issues, security issues, sustainability/ energy
            1.
    c. Supply Chain/ External

i. Governmental policy, lack of industry examples, market competition, challenges onboarding supply chain, Collaboratory challenges, cultural difference, data and information transparency issues

1.

5) **Strategies/ approaches/ resources** can organisations have/ or employ to minimise these disruptions? (Knowledge/ Experiential)
   a. Tech

      1.

   b. People

      1.

6) Thinking evolved **over time?** Future **different approaches**? (Opinion/ Values)

   1.

Close

1) I would just like to **clarify a couple of your responses**
2) Do you have a contact who you believe would be able to also provide similar insights into enterprise DLT adoption, with whom you would be willing to put me in touch with?
   a. You would need to reach out to them to gage their interest, and if they are interested, then you would put them in contact with me, either rover LinkedIn, email, or discord.
3) Thank you

Appendix D – Case Interview Schedule

Introduction

6) Hi, Nice to meet you
    a. **[Interviewee Name]**
    b. I have an information sheet and consent form about the interview, do you mind if I just send them over and you can have a read through them and ask any questions?
    c. Scheduled **[Time],** should be enough time but can I just ask are you flexible or do you need to go at…
7) Introduce me
    a. I'm Matthew
        i. PhD researcher and I am a student **lecturer at UoS**
            1. Mainly lecturing master's students
                a. Management accounting, strategic management, and supply chain technology
                b. Emphasize technology
8) Introduce my PhD research
    a. I am looking into how to **implement and scale blockchain** systems in supply chains and enterprises
        i. I am looking at barriers/ challenges, solutions, resources, and other contextual factors
    b. I am doing this by **interviewing people** who have **first-hand industry experience** working with blockchain technology, and have been part of the implementation, scaling, or establishment, or a blockchain project.
        i. The questions are on a specific case
            1. Use case of **[Case Name]**
    c. I am not 100% certain what format I want to **present the findings**/ results in, whether it be a framework, or some form of tool which can be used to aid organisations in implementing and/ or scaling their blockchain solution

i. I will be able to provide you with an **executive summary, or report**, of my findings as well.

1. Should be some time next year, probably in **Q2, or Q3**. Depends how many interviews I can get early

Setting Expectations

1) I have allotted **half an hour** for this discussion
    a. The interview usually takes 50 minutes to complete, so I am just conscious of time
2) I know we have spoken online before this, but don't worry about **repeating anything** you have already said
    a. It works better for me if the information is all in one place anyway
        i. just try and give as **much information as possible**.
3) This is a non-technical paper
    a. Business student, not software engineer
4) Do you have any questions?
5) **START THE RECORDINGS**
    a. **MH, [Interviewee Name], [Interview Time], [Interview Date]**

Open

1) **Background information** and your **experience** please?
    a. Time working with blockchain
        i.
    b. Role
        i.
2) **Background** on the _____ blockchain?
    a. What did the blockchain do (objective)?
    b. Who was working on the project? Were parts outsourced?
    c. Who was funding the project?

d. Who were the stakeholders of the project? –
e. What is the end goal of the project?
f. What state is the project in currently?

3) **Role** in relation to the _____ project?
    a. Day to day?
    b. Responsibility?
    c. Who did you have contact with?

Body

1) **Timeline of the implementation** of the _____ blockchain? **scope of the project**?
    a. What was the scope of the project?
    b. Did the project have several phases?
    c. What was the timeline of the project?
        i. Did this change during the project?
            1. Why?
2) What **problems did you encounter**?
    a. Were there organisational problems? Or what organisational considerations were accounted for in the development of the product
        i. Understanding of DLT -
        ii. Existing IT Department/ technical competence -
        iii. Financial constraints? Return on investment? –
        iv. Stakeholders -
        v. From my understanding this project has been outsourced in parts to other organisations, does this present a challenge? -
        vi. Management support/ commitment to the project? -
    b. Were there supply chain/ external issues?
        i. Legislative/ Gov policy issues -
        ii. Lack of industry examples? –

iii. Market competition in the sector -
iv. Onboarding difficulties -
v. Collaboratory challenges/ trust? –
vi. Cultural differences? –
vii. Data/ Info transparency issues? -

c. Were there technological challenges?
   i. Data collection –
   ii. Hardware/ software issues –
   iii. Immutability challenges -
   iv. Integration Issues -
   v. Scalability issues -
   vi. Security issues -
   vii. Sustainability/ energy –
   viii. Consortiums
      1. establish standards and common infrastructure
   ix. Standards -

3) **primary/ root cause** of these problems?
   a.
      i. At what phase did the majority of these problems occurred? – investigation/ poc / pilot / mvp / production etc
4) **Solve** these problems?
   a. Resources -
   b. Collaboration –
5) [If relevant] Would you say there was one, or a few, main reasons why the **project ultimately failed** and what were they? –
6) **Future approaches**? -
7) **Next steps for the project**? -
   a. **Challenges you foresee** occurring in the future? –
      i. Why? -
   b. **Steps are you taking to mitigate** these? -

Close

1) I would just like to clarify a couple of your responses
2) Do you have a **contact who also worked on the _____** who you think would be willing to discuss this? Perhaps someone on the strategic/ business side?
3) Do you happen to know anyone else, working on another project that fit these criteria, that may be willing to do an interview?
4) **Thank you**

Appendix E – Reflexive memo writing

Interview Participant 01

I feel like I managed the interview decently well. One area where I could improve is in how I handle asking about solutions to barriers. In the interview, I discussed barriers first, and then I discussed solutions after. This meant that solutions to some barriers may have not been discussed, especially if they were barriers which were mentioned earlier on in the interview. This could be done through improved probing during the discussion on challenges. I also think that the interview protocol could be improved to have a space where I can jot things down which the interviewee mentions, alongside the question which they were answering – so each question has an additional space for me to make notes as opposed to me just making notes on a separated document with no real structure to it.

Interview Participant 02

I felt that my performance in this interview was much better than in interview 1. In this interview I asked more probes throughout the interview. The changes to my interview protocol which I noted I will make after interview 01 were greatly beneficial. This allowed me to make notes on what the participant was saying, in a way where I could then access these and use them later during the interview as part of my probes. The interviewee commented several times that I was asking really good probing questions – which I hadn't originally planned for. The new interview protocol layout was a big reason for this. I also tried to address some solutions during the barrier's questions, which I believe made the interview flow more naturally than in the first interview. One area I was conscious of was that before the interview I didn't mention I would be note taking to the interviewee. So, to avoid them thinking I am not 100% engaged in the interview, I will state this before future interviews. That said, I do not believe this was an issue in this interview, as I think the probes I was asking, proved I was fully engaged in the interview.

Interview Participant 03

I did the consent form before I started the recording. This took up quite a lot of time. I think in future I am going to offer the participant the choice of doing the consent form at the start, or having a 15-minute meeting prior to the actual interview where we can discuss the interview, any questions they have, the consent form, and set a date for the actual interview. This way, more time can be spent on the interview, during the interview time, rather than the administrative processes as that will have been discussed and agreed previously.

I felt like I did a better job in this interview of clarifying the participants responses to ensure that I am able to accurately reflect the contents of the interview and their opinions in my analysis. I tried to use phrases such as 'just to clarify' to ensure that I accurately represented their opinions. Whilst I did set the expectations of the interview before hand – not a technical paper, on one specific case, etc – I feel the interviewee did not fully understand some of the points. Specifically, whilst the interview was on one specific case, the interviewee seemingly took this to mean that the [censored] product was the case, not the instance of one customer implementing the product. I need to better clarify this, both in my prior dialogue (or 15-minute chat with the participant), and just before the interview starts to ensure that the content is exactly what I am after.

Interview Participant 04

This interview took a while to get going, but when it did there was some really valuable insights made. The participant sometimes went off topic for some time. Sometimes I was able to use a probe to re-steer the conversation to the correct topic, other times I didn't. I will speak with my supervisors on how to handle this in the future. I felt my time management was very good in this interview as the participant had to go at the hour mark for another meeting, so I didn't 'over probe' unless I had indication that It would be worthwhile to do so. I also was able to ask my final question with 5 minutes left of interview time. Another area I did well here was I re-asked specific parts of my original question if I did not get an answer to that specific part. I felt that my probes were really good as some of his most insightful responses, were in response to a probe, or several probes. I am definitely

feeling more confident with my interview skills. Lastly, because of the speed with which this interview came about from the initial contact, I did not have an extensive understanding of the cases the participant had worked and the participant did not want a 15-minute chat beforehand; instead wanting to dive straight into the interview. As such, I planned to use the general interview transcript. However, it quickly became apparent that there was one case he had spent the most time on (3 years), and his other cases were all in their infancy (around 6 months). So, I made the decision during the first 5 minutes of the interview to pivot into discussing that one specific case and I think that this was the best decision as that one case would have been overrepresented in a more general discussion of DLT adoption and scaling.

Interview Participant 05

I made a mistake during this interview. The times had changed of this interview several times, and I thought it began at quarter past, so I was pacing the interview to be concluded by quarter past the next hour. But, it actually started at half past, so I was pacing the interview to be concluded 15 minutes earlier than it was scheduled to finish. I did realise my mistake and I went back to clarify and dig further into topics which I had previously moved on from, and this was very beneficial as some good insights were made in these last 15 minutes. This was largely because the note making system which I am now employing is much more effective than it was in the first interview as following my self-reflection, I am now making notes on the interview protocol in a different colour and section, that correlates back to each individual question. This means I can effectively 'tick off' certain topics, or I can make a note to dig deeper into a certain topic, or I can jot down a probe so that I don't forget it for later in the interview. During the interview I demonstrated each of these several times. Other than the pacing being slightly too fast, I feel I managed this interview well and asked good probes. Once I had asked all of my probes on technological barriers, I asked a much broader open-ended question, with the hopes that this would give the participant the opportunity to mention something that may not be discussed in the literature, however, I feel the question was actually too broad to the point where it didn't get any real response. Instead, I then pivoted the broad question into smaller questions

later on in the interview and that did allow for better responses. I will probably try and avoid asking highly open-ended, broad, and non-specific questions in the future.

Interview Participant 06

I feel this interview went really well. The participant had a PhD and had been involved in research projects before, so they were experienced in this type of setting. They also answered questions in a very logical manor which made managing the interview quite easy. However, the participant arrived late to the interview, so they interview started later than was scheduled. They also had to go at a certain time, so the interview could not run over at all. Because of this, I feel I managed the timings of the interview really well; however, I also feel like I could have kept asking questions for another 60 minutes to this participant as their answers were very in depth. I do feel the interview still captured the main points and thoughts of the participant as I asked open ended questions and discussed the sub-topics they chose to mention; however, I could have covered some more peripheral topics in greater depth if I had more time with the participant.

Interview Participant 07

I felt like my performance in this interview was quite inconsistent. Firstly, I adjusted my 'interview protocol for specific cases' to have separate spaces for me to note make during the interview and this was very helpful. I was able to make notes alongside the specific probes and I was able to add probes that I thought of during the interview. I also felt like I asked some questions which I had not planned to ask, which were insightful and elicited valuable insights into the topic from the participant. However, the participant was quite quiet, which meant I had to really concentrate to be able to accurately understand what they were saying. Because of this, I at times found myself listening closely to what he was saying, but then when he finished speaking, I would not have planned what question I was going to ask next, resulting in a pause as I tried to quickly select a question/ probe to ask. The participant also answered several of my questions with each response, and was providing very in-depth responses – which was excellent – so I had to jump around my

interview protocol in order to ask relevant probes to what he was mentioning and I feel I did this very well and that this is an area which I have made markable improvements on through the research project. If this interview was one of my first interviews, I may have struggled with this more than I did during this interview.

Interview Participant 08

This interview was the point where I started to make sense of a lot of the data that I had previously collected as the interviewee was really clear in emphasising what he believed to be the core issue facing blockchain projects – governance. The participant was very knowledgeable and spoke clearly which I believe contributed to the ease of the discussion. I felt my probing questions were better than in some of my earlier interviews. The notes which I made using the template were very helpful as I was able to allow the participant to explain his points, before using probes to direct the conversation back towards the key details. This interview felt very natural and was one of the interviews I was most pleased with. This has improved my confidence as an interviewer going forward.

Interview Participant 09

Due to scheduling being busy, this interview memo was not written immediately after the interview. I found this interview quite difficult to dissect as upon reflection of the audio recording. I have noticed that the participant gives lots of examples – which is great – but it is not 100% clear if the interviewee is citing cases that she is aware of, or if she is citing cases which she has worked on. In some cases this is clear however, in others it is less obvious. Unfortunately, I didn't pick up on this during the interview and as a result, I didn't probe as effectively as I would have liked. In future I will try to be aware of this potential issue so that I can notice it as it is occurring, and I can then probe as a means of gaining the understanding of if the participant is referencing first hand or second-hand experiences.

Interview Participant 10

I felt I had good rapport with this interviewee. However, because of this, this interview was extremely long as there were lots of tangents which I afforded the interviewee time to discuss before directing the conversation back to the research questions. This allowed for the interviewee to explore topics in greater detail where he may mention something which was relevant to the research questions, but that wouldn't have come up in a shorter interview. We discussed the time that the interview would take, and the interviewee made it clear that he had a lot of time as he was on an evening of a business trip where he did not have plans for the next few hours. Thus, I allowed the interview to be more explorative and discuss peripheral topics in greater detail. One issue with this interview was that I feel I got worse with my use of probes and concentration as the interview got to around 2+ hours in length as due to the time difference (UK to Vietnam), I was struggling with fatigue towards the end of the interview. Also, because the interview was longer, I made more notes, which made my template less clear. In future If another participant affords me as long for the interview, I will be more selective with what I include in the template so that the template remains readable and can be used as a quick guide at a glance.

Interview Participant 11a and 11b

This interview was very interesting. It was my first group interview of the project. It was a group interview because one of the participants offered to recruit another participant (who was initially unknown to me, but I was assured she fit the criteria), as long as they could do the interview together, but was not willing to do the interview alone. Once the other person agreed, the initial participant introduced us to each other and – as was previously assured to me – they did fit the criteria. They are not from the same organisations, rather they are just friends within the same industry – blockchain.

Interestingly, I found the group interview had disadvantages and advantages compared to a regular one-to-one interview in terms of topic. In this interview, both participants would sometimes end up going quite far off topic with their answers to my questions. I allowed this as I had scheduled nearly two hours for the interview so I could afford to allow the conversation to go on tangents on occasion as long as I brought it back if I felt it had strayed

too far. However, sometimes the participants would ask each other probes which were of interest to them. In some cases, this was really helpful as it redirected the conversation back onto the intended topic, but on some occasions, this directed the conversation further away from the intended topic so it really felt like a double-edged sword in some ways. Thankfully, I had allotted a longer amount of time for the interview so this allowed me to steer the conversation back more naturally rather than abruptly interjecting which I would have had to do in a shorter interview.

Interview Participant 12

This interview was one of the more difficult to manage. The interviewee had recently launched a start-up blockchain project. Despite this not being the main focus of the interview, the participant often brought up the new product/ service in a way that felt like he was pitching the product to me. This meant that sometimes questions would not be answered in an expected way, as he would often attempt to pivot the conversation toward his new start-up. As a result of this, I was undecided mid-interview about if I should switch the interview to a case interview, and focus on his new product, or if I should stick with the original general interview plan. As a result, some of the probes were targeted more towards the single case whereas others were phrased generally. Despite this, the participant was very knowledgeable and experienced with blockchain projects and some useful data was obtained – especially around governance best practices which was something which had not been explored in as great depth to this point. I also feel rapport was very good during this interview and that the participant was very conversational.

Interview Participant 13

This interview was tricky as there was a shorter time constraint on the interview than the others as the participant could only allot half an hour to the interview. However, he was also experiencing technical difficulties with his audio, so the interview ended up starting 10 minutes late which would have left only 20 minutes for an interview. We had previously scheduled two other meetings. The first was cancelled and for the second the participant

arrived 15 minutes late so we decided to reschedule. Because of this, I decided to just try and collect as much data from the participant as possible in the 20 minutes that remained, rather than suggesting we reschedule a fourth meeting. I could have asked at this point if he was okay to extend the interview but I elected not to as rapport had not yet been built and I believe he thought I was late to the meeting because he messaged me stating hes sat here waiting for me but it was because he had joined the meeting in a companion mode (which I had never heard of and had thus not planned for this eventuality), which does not allow you to see other participants in the meeting, meaning he couldn't see me. I messaged him back explaining this and he re-joined the meeting and everything was now working correctly. This meant that I did not probe in some areas where the opportunity arose, as I was conscious of the time constraint. However, to ensure a decent level of depth, I initially narrowed the scope of the interview to focus on the barriers to DLT implementation, rather than to focus on barriers and solutions. However, as we approached the end of the meeting I asked if he was okay for time, and he said he would be happy to give me an extra 10 minutes. I (rather subjectively) feel this was helped by the fact that we had built up more of a rapport over the duration of the meeting. In these final ten minutes I decided to expand the scope of the interview to again include some solutions as he had offered up information on solutions throughout the course of the interview anyway. Ultimately, this interview presented me with a lot of unique decisions which I needed to make quickly, which I feel I handled in a rather considered way.

Interview Participant 14

This interview participant and this interview was very similar with one of the earlier interviews I did because they each religiously emphasised the importance of governance in relation to my research question. I feel I did well in this interview in clarifying the participants responses which was necessary on occasion due to the participant having a strong accent and the internet connection not being amazing which caused the audio to be a bit sporadic in places. I also feel I did a good job of noting things the participant said, and then revisiting these later on in the interview. This allowed me to not break to flow of the current topic and allowed me to probe further on the current topic, but then to also be able to revisit some of the tangents later on in the interview. I felt like rapport was also built

early on in this interview as there was a very relaxed feeling to the interview. This could be attributed to the 10-minute discussion we had before the interview just going over the research topic and allowing him another opportunity to ask any questions which he may have had.

Interview Participant 15

Interview Participant 16

This interview was extremely interesting. I had wanted to interview a senior individual at this organisation because several other interviewees had explained how this organisation was considered the 'gold standard' in blockchain applications. He felt very passionately that the more conventional private permissioned blockchains were inferior to public permissioned blockchains – this was a position other interviewees had mentioned, but his beliefs were displayed with greater conviction than other interviewees, throughout the interview. Thus, he provided a very valuable insight which, when coupled with other interviewees acknowledging public may be superior despite being invested in private, he may be ahead of the curve with his understanding of blockchain applications. Unfortunately, I was only able to conduct a 30-minute interview with the participant due to their schedule. However, as I had conducted several shorter interviews at this point, I felt more comfortable in navigating the topics. However, I took a different approach to this interview, recognising the passion the interviewee had about certain topics. Thus, I elected to probe and attain a greater depth in areas where the participant was passionate, or had an opinion which conflicted with the consensus from the majority of other interviews. This flexible approach allowed me to gain a better insight into his rationale for his more contentious positions, which I felt was more valuable than simply deciding prior to the interview to prioritise one specific research question. Rapport was built very quickly with the interviewee as his workspace had objects which were on display which we had common interests in. As a result, prior to starting the recording, as well as the usual discussion which occurred with

each interviewee, I also asked questions about our common interest and we had a short friendly discussion prior to data collection. I feel this was necessary as to this point, all communications with the interviewee had been conducted through his secretaries, so I was unsure what knowledge the interviewee had about the project or who I was. Thus, before the interview this allowed me to build rapport whilst explaining my research and clarifying the scope of the project.

Interview Participant 17

This interview was quite different from the one conducted previously. Firstly, the participant was less experienced and as a result, I feel he spoke with less confidence about his subject. However, I felt that I wanted a mixture of seniority levels as I wanted to capture the strategic and tactical, but also operational perspectives. Secondly, the interviewee wasn't the most conversational and as a result, I was having to probe quite frequently to get the information which was required. As a result, the interview jumped between topics quite a lot when the participant started to become more conversational in the later stages of the interview. Lastly, this interview was conducted on short notice because the participant wanted to do it at a closer date. Thus, I was unable to sufficiently research his company and the specifics of what his companies service and product offering is in his country. Thus, some of the probes were more basic and were asking questions which were available online; however, this was unavoidable due to the short turnaround between initial contact and the interview taking place. Despite these three factors, I believe the interview still had very important data, especially around processes and strategy that are being used when working directly with the deployment lead organisations.

Appendix F – Initial Template of Codes

Hierarchical list of codes	Files	References
Barriers	0	0
External	12	183
Environmental	10	47
Industry Challenges	5	19
Blockchain value is industry specific	1	2
Different industries have different levels of understanding of blockchain technology	2	5
Ease of blockchain deployment is industry dependent	3	8
Lack of external examples of using blockchain as sole data management system	2	4
Miscellaneous Environmental Challenges	2	4
External factors can inhibit an organisations ability to invest financial resources to blockchain	1	1
Some countries don't want blockchain to reveal their corruption	1	3
Perception	8	14
Blockchain suffers from its own hype	6	9
Crypto influences understanding of blockchain	4	4
Crypto news can impact perceptions of enterprise blockchain	1	1
Regulatory and legislative challenges	5	10
Different regulation in different sectors	1	1
lack of regulation incentivising blockchain	1	1
Public sector cross jurisdictional challenges	1	5
Regulatory and governing body agendas	1	1

Governance	12	136
Maintenance Challenges	4	7
Competing stakeholder interests and objectives	1	1
Establishing blockchain maintenance in governance	2	2
Governance structures are difficult to maintain when issues arise	2	3
Suppliers creating legal hurdles for the network	1	1
Onboarding Challenges	12	129
Off-chain governance challenges	12	77
Geographical Challenges	7	16
Cultural supply chain challenges	1	3
Lack of technical expertise in some geographies	1	1
Multi geographic supply chain challenges	5	12
Identity Specific Challenges	9	15
Difficulties onboarding risk averse members	1	1
Failure to onboard key partners	2	4
Onboarding competitors challenges	2	2
Poor relationships with supply chain members	2	4
Quantity of onboarded organisations	3	4
Lack of standardisation for onboarding	2	4
Supplier Financial Challenges	1	2
Issues with unbanked small businesses	1	1

Onboarding too expensive for suppliers	1	1
Supply Chain Competencies Challenges	8	22
Lack of internet access in supply chain	1	2
Low existing supply chain digitalisation	7	17
Low supply chain understanding of blockchain technology	2	3
On-chain governance challenges	12	52
Deciding what data is stored on-chain	2	2
Difficult to establish initial governance structures	2	5
Disagreements around infrastructure, node hosting, and data ownership	2	9
Disagreements around level of decentralisation	2	2
Disagreements around on-chain permissions	12	28
Data privacy challenges on public blockchains	1	1
Lack of desire to share data	2	2
Lack of supplier trust in how the data will be used	2	3
Lack of trust in the data	2	3
Refusal to share product secrets	2	3
Organisational	12	158
Consultant Challenges	6	15
3rd parties can have blockchain platform preferences and biases	2	5
Advertisement Dishonesty	3	5

3rd Parties making false marketing claims	1	1
Some 3rd parties don't have the technological expertise they claim to have	3	4
Blockchain providers lacking regulatory or industry understanding	2	5
Financial Challenges	6	27
Deployment costs	2	4
Blockchain deployment is resource intensive	1	1
Challenges justifying deployment costs for very small suppliers	1	1
Supporting technologies increase deployment costs	1	1
Funding Sourcing	1	1
Difficulties establishing funding when ground-up initiation	1	1
Maintenance costs	4	7
Customer support costs	1	1
Maintenance as a hidden-cost	1	1
Supporting technologies maintenance costs	1	1
Uncertainty	2	8
Cost forecasting inaccuracy	2	8
Technical issues increase costs	1	2
Web3 directionality uncertainty increasing maintenance costs	1	1
Workforce Costs	2	3
Cost of labour	1	1
Experienced developers are expensive	2	2
Mindset	8	30
Attitudes	7	20
Blockchain currently for early adopters	1	3

Organisation mindset has yet to fully trust the switch to blockchain	6	16
The perception that blockchain is new	1	1
Motivations	5	10
Blockchain for marketing purposes	3	4
Blockchain for the sake of blockchain	4	6
Organisation Size	6	9
Larger Organisation Challenges	4	6
Large organisations have more stakeholders	1	1
Larger organisations have more legal hurdles and bureaucracy	3	4
Smaller Organisation Challenges	3	3
Smaller organisations have fewer blockchain competencies	1	1
Smaller organisations have fewer resources and influence throughout their supply chain	2	2
Product Challenges	1	2
Product transformations make traceability and data collection harder	1	2
Return on Investment Challenges	12	52
Difficult to establish the expected ROI	2	4
Lack of desired ROI within budget period	8	13
Necessity for blockchain ROI to add value	10	35
Workforce	8	23
Disputes	3	5
Conflict between IT departments and 3rd party consultants	1	1
Inter departmental disputes	2	4
Lack of understanding	7	15
Lack of blockchain expertise	7	14

Improving internal tech competencies takes a long time	1	1
Lack of understanding of their supply chain	1	1
Upper Management Challenges	2	3
Blockchain not the highest priority	1	1
Business personnel underrepresentation in the project	1	2
Technological	12	148
Blockchain Platforms	8	20
Blockchain platforms have different quantities of developers and open source material	2	3
Difficulties keeping software up-to-date	2	2
Indecision between blockchain platforms	8	14
Potential need to switch to a new blockchain in the future	1	1
Blockchain Type	6	15
Indecision between public or private blockchain	4	4
Private and public blockchains present different challenges	2	2
Private Blockchain Challenges	1	8
Private blockchains don't scale	1	4
Private blockchains offer less value than public	1	4
Public Blockchain Challenges	1	1
Public blockchain security issues	1	1
Data Collection Challenges	11	59
Circumstantial Data Collection Challenges	9	33
Blockchain objective specific challenges	6	15
Industry specific challenges	5	9
Product Specific Data Collection	4	9

3rd party certification can be very difficult to attain	1	2
Data collection is product specific	3	7
Data Accuracy Challenges	9	25
Blockchain requires lots of points of data collection	2	2
Collecting fraudulent or inaccurate data	6	12
Data collected from network partners	4	4
Difficulty collecting absolutely assured data	1	3
Manual data collection challenges	3	4
Functionality Challenges	11	54
Blockchain accessibility and intractability	3	3
Challenges deploying accompanying applications	1	1
Blockchain still in a state of relative infancy	5	16
Data security issues	1	2
Integration Challenges	9	20
cross-chain integration increasing complexity	5	6
Integrating blockchain with legacy systems	5	12
Integrating blockchain with supporting technologies	2	2
Interoperability challenges	1	1
Payment rail challenges	1	2
Smart contract challenges	3	3
Supporting Technology Challenges	4	7
Infancy of supporting technologies	1	2
Introducing supporting technologies increases complexity	3	5

Appendix G – Data Management Plan

Defining your data

Where does your data come from?

How often do you get new data?

How much data do you generate?

What format(s) are your data in?

If pre-existing datasets are being used, where will these come from? How will they be used? Who owns them?

Data will be collected through several sources. The primary data will be collected using semi-structured interviews. The secondary data will be collected in the form of documentation.

Primary data will be in the form of interview transcriptions. Interviews will aim to be conducted at a rate of between two and four per month, over an 8-month period (16-32 interviews). This number is an approximation as the quantity of data will be dictated by the data analysis. Once the analysis procedure has developed a theorem that has been tested by collecting further interview and documentary data that supports the theorem. Interviews will be between one hour and two hours in length. Primary data will be formatted as an interview transcript. Secondary data will be formatted as documentation. Data will be stored electronically using NVivo (or a substitute programme).

Looking after your data

What different versions of each data file do you create?

What additional information is required to understand each data file?

Where do you store your data?

How do you structure and name your folders/files?

How is your data backed up?

How will you test whether you can restore from your backups?

What safeguards will you put into practice?

Data files will be securely stored in encrypted files in the University of Sheffield Google Drive. During the PhD process, myself and my supervisors will have access to the data. All folders containing the data will be password encrypted. Folders containing data will be separated by participant. Each participant will have a unique identifier. There will be one document that states which unique identifier belongs to which participant. This will again be password encrypted and deleted upon completion of the research project. Any documentation will also be placed in folders alongside the participant who provided it. Data will be managed inside of NVivo where it will be grouped based off of its contents - not by participant. Data will be destroyed three years after the PhD has been disseminated into the academic community.

Data files will be backed up to my personal university cloud. This will be tested by making a minor adjustment to a file and checking that adjustment is made in the cloud. Again, data will be anonymised for every individual using a unique identifier that will only be written on one document.

Archiving your data

What should be archived beyond the end of the project?

For how long should it be stored?

When will files be moved into the archive?

Where will the archive be stored?

Who is responsible for moving data to the archive and maintaining it?

Who should have access and under what conditions?

All archived data will be anonymised to ensure participant confidentiality. The raw data will be archived. Each segment of the data will also be archived alongside the corresponding memos. This will include notes pertaining to the process. All documentation will also be archived. Archived data will be stored until three years after the PhD's publication. The archive will be stored at SUMS and I, Matthew Hinchliffe, am responsible for moving the correct data into the archive. During the PhD process, myself and my supervisors will have access to the data.

Sharing your data

Could any of your data be considered sensitive personal data under the GDPR?

Does permission need to be obtained for future re-use and sharing?

Have participants transferred copyright (if necessary)?

Who else has a right to see or use this data?

Who else should reasonably have access?

What should/shouldn't be shared and why?

The anticipated data is not sensitive personal data as it concerns organisations. Yes, permission does need to be obtained to further use or share the data. Transferring of copyright is not necessary to this project. I have right to see and use this data, my supervisors have a right to see this data. University of Sheffield approved transcription

services may be used. If they are used, data will be encrypted and University of Sheffield procedures will be followed. No one else has access outside of the research team.

Implementing your plan

Who is responsible for making sure this plan is followed?

How often will this plan be reviewed and updated?

What actions have you identified from the rest of this plan?

What further information do you need to carry out these actions?

The primary research team (researcher and two supervisors) are responsible for ensuring that this plan is followed. This plan may be adjusted if any data collection or data analysis strategies change at any point throughout the research. If adjustments are made, University of Sheffield policy will be followed to ensure cooperation with ethical practices. However, this plan will be reviewed annually if nothing changes. No further actions have been identified as a result of this plan.

Appendix H – Final Template

Category/ Code	Files	Ref
1. Environmental Barriers	16	92
1.1 - Industry Challenges	**10**	**36**
1.1.1 - 3rd party Intermediary problems	1	2
1.1.2 - Different industries have different levels of understanding of blockchain technology	3	7
1.1.3 - Ease of blockchain deployment is industry dependent	5	19
1.1.4 - Lack of external examples	5	8
1.2 - Marketing Challenges	**9**	**17**
1.2.1 - Blockchain suffers from its own hype	6	9
1.2.2 - Crypto influences understanding of blockchain	5	5
1.2.3 - Crypto news can impact perceptions of enterprise blockchain	2	3
1.3 - Miscellaneous Environmental Challenges	**2**	**4**
1.3.1 - External factors can inhibit an organisations ability to invest financial resources to blockchain	1	1
1.3.2 - Some countries/ companies don't want blockchain to reveal their corruption	1	3
1.4 - Regulatory and Legislative Challenges	**11**	**37**
1.4.1 - Governing body agendas and-or standards challenges	5	10
1.4.2 - Different regulation in different countries	5	14
1.4.3 - Different regulation in different sectors	3	4
1.4.4 - Lack of regulation incentivising blockchain	1	1
1.4.5 - Regulation disincentivising or prohibiting blockchain features or functions	3	6
2 Governance Challenges*	**18**	**384**

Category/ Code	Files	Ref
2.1 - Maintenance Challenges	**6**	**19**
2.1.1 - Competing stakeholder interests and objectives	3	13
2.1.2 - Establishing blockchain maintenance in governance	2	2
2.1.3 - Governance structures are difficult to maintain when issues arise	2	4
2.2 - Onboarding Challenges	**18**	**357**
2.2.1 - Off-chain governance challenges*	**18**	**283**
2.2.1.1 - Geographical Challenges	10	24
2.2.1.1.1 - Cultural supply chain challenges	3	9
2.2.1.1.2 - Lack of technical expertise in some geographies	1	1
2.2.1.1.3 - Multi geographic supply chain challenges	6	14
2.2.1.2 - Identity Specific Challenges	13	27
2.2.1.2.1 - Conflicting roadmaps and schedules	2	2
2.2.1.2.2 - Difficulties onboarding risk averse or highly regulated members	2	5
2.2.1.2.3 - Failure to onboard key partners	3	6
2.2.1.2.4 - Onboarding competitors challenges	3	3
2.2.1.2.5 - Poor relationships with supply chain members	3	5
2.2.1.2.6 - Quantity of onboarded organisations	5	6
2.2.1.3 - Lack of collaborative business models	7	23
2.2.1.4 - Lack of incentive to join the network	17	83
2.2.1.5 - Lack of power or influence over supply chain	11	30
2.2.1.6 - Lack of rights and-or lack of clarity of rules of engagement	9	19
2.2.1.7 - Lack of standardisation for onboarding	6	18
2.2.1.8 - Supplier Financial Challenges	3	13
2.2.1.8.1 - Issues with unbanked businesses	1	1

Category/ Code	Files	Ref
2.2.1.8.2 - Lack of clarity in funding sources	3	11
2.2.1.8.3 - Onboarding too expensive for suppliers	1	1
2.2.1.9 - Supply Chain Competencies Challenges	10	26
2.2.1.9.1 - Lack of internet access in supply chain	1	2
2.2.1.9.2 - Low existing supply chain digitalisation	9	21
2.2.1.9.3 - Low supply chain understanding of blockchain technology	2	3
2.2.2 - On-chain governance challenges*	**15**	**74**
2.2.2.1 - Deciding what data is stored on-chain	4	12
2.2.2.2 - Difficult to establish initial governance structures	3	10
2.2.2.3 - Disagreements around infrastructure	5	14
2.2.2.4 - Disagreements around on-chain permissions*	14	32
2.2.2.4.1 - Data privacy challenges	2	2
2.2.2.4.2 - Lack of desire to share data	3	3
2.2.2.4.3 - Lack of supplier trust in how the data will be used	2	3
2.2.2.4.4 - Lack of trust in the data	2	3
2.2.2.4.5 - Refusal to share product secrets	2	3
3 - Organisational Barriers	**18**	**318**
3.1 - Consultant Challenges	**10**	**35**
3.1.1 - 3rd parties can have blockchain platform preferences and biases	4	8
3.1.2 - Advertisement Dishonesty	5	14
3.1.3 - Blockchain providers lacking regulatory or industry understanding	3	8
3.1.4 - Poor communication between 3rd party developers	1	4
3.2 - Mindset Challenges	**10**	**39**

Category/ Code	Files	Ref
3.2.1 - Attitudes	**8**	**26**
3.2.1.1 - Blockchain currently for early adopters	2	4
3.2.1.2 - Organisation mindset has yet to fully trust the switch to blockchain	6	16
3.2.1.3 - Risk Averse and anti-innovation	1	6
3.2.2 - Motivations	**7**	**13**
3.2.2.1 - Blockchain for marketing purposes	3	4
3.2.2.2 - Blockchain for the sake of blockchain	6	9
3.3 - Organisation Size Related Challenges	**10**	**18**
3.3.1 - Larger Organisation Challenges	**7**	**12**
3.3.1.1 - Large organisations have more stakeholders	3	3
3.3.1.2 - Larger organisations have more legal hurdles and bureaucracy	6	8
3.3.2 - Smaller Organisation Challenges	**6**	**6**
3.3.2.1 - Smaller organisations have fewer blockchain competencies	1	1
3.3.2.2 - Smaller organisations have fewer resources and influence throughout their supply chain	5	5
3.4 - Product Challenges	**3**	**5**
3.4.1 - Lack of standardisation between product lines	1	1
3.4.2 - Product transformations make traceability and data collection harder	2	4
3.5 - Resource Challenges	**11**	**36**
3.5.1 - Financial Challenges	**9**	**32**
3.5.1.1 - Deployment costs	4	8
3.5.1.1.1- Blockchain deployment is resource intensive	1	1
3.5.1.1.2 - Challenges justifying deployment costs for very small suppliers	3	5

Category/ Code	Files	Ref
3.5.1.1.3 - Supporting technologies increase deployment costs	1	1
3.5.1.2 - Funding Sourcing Challenges	1	1
3.5.1.3 - Maintenance costs*	4	7
3.5.1.3.1 - Customer support costs	1	1
3.5.1.3.2 - Maintenance as a hidden-cost	1	1
Supporting technologies maintenance costs	1	1
3.5.1.3.3 - Cost forecasting uncertainty	3	9
3.5.1.3.3.1 - Technical issues increase costs	1	2
3.5.1.3.3.2 - Web3 directionality uncertainty increasing maintenance costs	1	1
3.5.1.4 - Workforce Costs	2	3
3.5.1.4.1 - Cost of labour	1	1
3.5.1.4.2 - Experienced developers are expensive	2	2
3.5.2 - Non-financial Resource Challenges	**4**	**4**
3.5.2.1 - Low existing digitalisation	4	4
3.6 - Return on Investment Challenges	**18**	**102**
3.6.1 - Blockchain not aligned with business goals	3	5
3.6.2 - Difficult to establish the expected ROI	9	22
3.6.3 - Lack of desired ROI within budget period	8	13
3.6.4 - Necessity for blockchain ROI to add value	16	62
3.7 Workforce Challenges	**15**	**83**
3.7.1 - Disputes	4	12
3.7.1.1 - Conflict between IT departments and 3rd party consultants	2	5
3.7.1.2 - Inter departmental disputes	3	7
3.7.2 - Lack of understanding	**15**	**41**
3.7.2.1 - Lack of blockchain expertise	15	39
3.7.2.2 - Lack of understanding of their supply chain	2	2
3.7.3 - Upper Management Challenges	**11**	**30**

Category/ Code	Files	Ref
3.7.3.1 - Business personnel underrepresentation in the project	1	2
3.7.3.2 - Lack of Upper Management Support	6	14
3.7.3.3 - Project management approach challenges	2	8
3.7.3.3.1 - Business operations and strategy challenges	4	6
4 - Systems Barriers	**16**	**94**
4.1 - Data Collection Challenges*	**17**	**115**
4.1.1 - Circumstantial Data Collection Challenges	**14**	**40**
4.1.1.1 - Blockchain objective specific challenges	7	16
4.1.1.2 - Industry specific challenges	6	10
4.1.1.3 - Product Specific Data Collection	8	14
4.1.1.3.1 - 3rd party certification challenges	2	3
4.1.1.3.2 - Data collection is product specific	6	11
4.1.2 - Data Accuracy Challenges	**14**	**73**
4.1.2.1 - Blockchain requires lots of points of data collection	3	3
4.1.2.2 - Collecting fraudulent or inaccurate data	8	20
4.1.2.3 - Data collected from network partners	4	4
4.1.2.4 - Difficulty collecting absolutely assured data	5	14
4.1.2.5 - Lack of standardisation of the data between partners	9	24
4.1.2.6 - Manual data collection challenges	4	6
4.1.2.7 - Syncing the digital data with the physical assets	1	2
4.2. Functionality Challenges	**17**	**126**
4.2.1 - Blockchain accessibility and interactability	9	23
4.2.2 - Blockchain still in a state of relative infancy	8	22
4.2.3 - Data security issues	5	14
4.2.4 - Integration Challenges	14	37
4.2.4.1 - Blockchain Interoperability	5	7

Category/ Code	Files	Ref
4.2.4.2 - Integrating blockchain with legacy systems	8	19
4.2.4.3 - Integrating blockchain with the technology stack	5	12
4.2.5 - Lack of standardised maintenance of technology	1	3
4.2.6 - Payment rail challenges	1	2
4.2.7 - Smart contract challenges	5	6
4.2.8 - Supporting Technology Challenges	5	8
4.2.8.1 - Infancy of supporting technologies	2	3
4.2.8.2 - Introducing supporting technologies increases complexity	3	5
4.2.9 - Tokenisation of digital assets	3	5
4.2.10Transaction throughput speed	3	5
4.3 - System Decision Challenges	**13**	**58**
4.3.1 - Blockchain Platforms	**12**	**35**
4.3.1.1 - Blockchain platform resource challenges	2	3
4.3.1.2 - Blockchain update challenges	4	7
4.3.1.3 - Indecision between blockchain platforms	11	22
4.3.1.4 - Potential need to switch to a new blockchain in the future	3	3
4.3.2 - Blockchain Type	**10**	**23**
4.3.2.1 - Indecision between public or private blockchain	6	7
4.3.2.2 - Private and public blockchains present different challenges	3	3
4.3.2.3 - Private Blockchain Challenges*	2	11
4.3.2.3.1 - Private blockchain data security issues	1	2
4.3.2.3.2 - Private blockchains don't scale	1	4
4.3.2.3.3 - Private blockchains offer less value than public	1	4
4.3.2.4 - Public Blockchain Challenges	2	2
4.3.2.4.1 - Public blockchain security issues	2	2