The Effects of Blockchain on Supply Chain Trust

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Abstract

Enterprises place strategic importance on supply chains to effectively manage their flow of materials, products, and information. Supply chains primary aim is to have the right product, at the right place, at the right cost, at the right time. Therefore, any gain in efficiency leads to a competitive advantage for the enterprise. A key element to achieving differentiation from competitors is through collaborative partnerships with supply chain suppliers and ultimately, this is achieved by the presence of high-level trust amongst stakeholders.

The academic pursuit of this research paper is to explore the type of trust found in supply chain relationships and what effect the adoption of an innovative technology like blockchain would have on trust. Through a thorough literature review, this research thesis addresses comparisons of types of trust, the importance of trust and how trust is achieved in supply chains.

Blockchain is, by all definitions, a nascent technology and this amplifies concerns of risk from enterprise and further increases its barriers to adoption. This research thesis argues that blockchain is particularly exposed to a slow rate of adoption due to a lack of knowledge of what distinguishes it from other exponential technologies. In arguing this the research seeks to answer the question: how does blockchain affect trust in supply chain relationships?

Through the development of a survey and semi-structured interviews, responses capture the attitude of supply chain professionals surrounding perceived trust in their supply chain, their piloting of exponential technologies and the biggest inhibitors they have experienced to implementing blockchain in their organisations.

One of the conclusions of this research is that through the successful implementation of blockchain, enterprises are likely to see increased trust, sustainability, visibility, and efficiency. This cannot be achieved however without an increased understanding from management about the technology, its use cases, and the efficiencies it will bring to a modern, resilient, and adaptive supply chain. This research establishes that the future for blockchain is optimistic if greater awareness of the technological benefits is exposed to the supply chain industry and its various stakeholders.

Acknowledgments

Firstly, I would like to thank my family for their unending patience and support while I wrote this thesis. This one is for my children, Charlie, and Grace to show them that learning is a lifelong quest, and you should always thirst for knowledge no matter your age.

To Alan Win, a gentleman and a scholar and my supervisor who has been paramount to get me through this research thesis. I am forever indebted to your generosity and for believing in me to get this across the line.

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Table of contents

Abstract **2**

Acknowledgments **3**

Table of contents **4**

List Of Figures and Tables **6**

1. Introduction **8**
- **1.1 Background** **8**
- **1.2 Research Questions and Objective** **8**
- **1.3 Scope and Boundaries of the Research** **8**
- **1.4 Importance of the Research** **9**
- **1.5 Flow and Contents of Remaining Chapters** **9**

2. Literature Review **10**
- **2.1 Introduction** **10**
- **2.2 Definitions of Trust** **10**
  - 2.2.1 Comparative Definitions of Trust 11
  - 2.2.2 Supply Chain Trust and its Role in Supply Chains 12
  - 2.2.3 Importance of Trust in Supply Chains 13
  - 2.2.4 Trust in Strategic Management 14
- **2.3 Innovation in a Fast-paced Digital Evolution** **15**
- **2.4 Supply Chain Trends and Emerging Technologies** **16**
  - 2.4.1 Artificial Intelligence (AI) 16
  - 2.4.2 Internet of Things (IoT) 17
  - 2.4.3 Robotic Process and Automation (RPA) 18
  - 2.4.4 Big Data Analytics 19
  - 2.4.5 Industrié 4.0 19
- **2.5 Blockchain** **21**
  - 2.5.1 History of Blockchain and Bitcoin 23
  - 2.5.2 Blockchain Research, Development and Implementation 24
  - 2.5.3 Enhancing Traceability 25
  - 2.5.4 A Counterfeit Can be Traced to its Source Using the Blockchain Trail 26
  - 2.5.5 Increasing Efficiency and Speed and Reducing Disruptions 26
- **2.6 Advantages of Blockchain Technology** **27**
- **2.7 Challenges and Current Limitations of Blockchain Technology** **28**
  - 2.7.1 Centralised or Decentralised? 28
  - 2.7.2 Computational Power and Knowledge 28
- **2.8 Supply Chain Trust Through Blockchain** **29**
- **2.9 Conceptual Model** **29**
- **2.10 Summary of Most Important Aspects of Literature** **32**
- **2.11 Research Gap** **32**

3. Research Methodology **33**
- **3.1 Detailed Descriptions of Research Question** **33**
- **3.2 Research Methods Overview** **33**
- **3.3 Ontological Perspectives** **34**
- **3.4 Epistemological Perspectives** **34**
- **3.5 Appraisal of Alternative Research Methodologies** **35**
  - 3.5.1 Quantitative and Qualitative Methods 35
  - 3.5.2 Mixed Methods Approach 36
- **3.6 Selection of Research Methodology** **36**
- **3.7 Detailed Description of Research Approach** **37**

3.8 Ethical Considerations 40

4. Analysis 41
4.1 Introduction 41
4.2 Data Collection Methods 41
4.2.1 Sampling and Criteria Requirement 41
4.2.2 Web Surveys 42
4.2.3 Survey Development 42
4.3 Data Analysis Methods 43
4.4 Statistical Validation Process 43
4.5. Findings & Discussion 45
4.5.1 Introduction 45
4.5.2 Findings: Company Profile 45
4.5.3 Findings: Elements for Success and Trust in Supply Chain Relationships 48
4.5.4 Findings: General Discussion 51
4.5.5 The Importance of the Variable 'Knowledge' Regarding Blockchain 52
4.5.6 Blockchain Projects Amongst Respondents 53
4.5.7 Review of Findings 55

5. Conclusion 56

Bibliography 59

APPENDIX A – COVER EMAIL/INTRODUCTION FOR SURVEY 70

APPENDIX B – SURVEY QUESTIONS 71

APPENDIX C – CORRELATION ANALYSIS OF VARIABLES 72

APPENDIX D – CODE BOOK FOR QUANTATIVE ANALYSIS OF VARIABLES 73

APPENDIX E – DATA FOR QUANTATATIVE ANALYSIS OF VARIABLES 74

APPENDIX F – THEMATIC CONTENT ANALYSIS 76

List Of Figures and Tables

Figure 2.1: Dynamics of trust in today's changing supply chain environment (Fawcett, et al., 2012) 11
Figure 2.2: Stages of Trust development along time, experience and relationship (Fawcett, et al., 2012) 14
Figure 2.3: Trust, performance and commitment capability matrix Source: (Fawcett, et al., 2012). 15
Figure 2.4: Reference architecture for IoT-based smart factory (Source: Shrouf et al., 2014) 18
Figure 2.5: Current payment system vs Bitcoin direct payment (Source: Deloitte n.d.) 21
Figure 2.6: The three most common types of networks (Source: Garzik & Donnelly, 2017). 22
Figure 2.7: Blockchain: How It Works (Source: PwC 2017) 22
Figure 2.8 – Proposed Model of Trust (Mayer et al., 1995) 30
Figure 2.9 – Conceptual model to value-add in the Supply Chain via blockchain (Source: Created for this thesis) 31
Figure 3.1 – An Outline of the main Steps of Qualitative Research (Source: Bryman 2012) .. 38

Table 2.1: The eight conceptual paradigms of trust (Source: Handfield, 2003) 11
Table 2.2: Blockchain development timeline (Source: Grant Thornton International, 2017; Gupta & Gupta Vinay, 2017) 23
Table 3.1 – Advantages and disadvantages identified in supply chain adoption of blockchain (Source: Created for this thesis) 33
Table 3.2: Fundamental Differences between Quantitative and Qualitative Research (Source: Bryman & Bell 2011) 35
Table 3.3 – Summary of author's approach to research (Source: Created for this thesis) 37
Table 3.4 – Descriptors of Research Design (Source: Cooper, & Schindler 2008) 37
Table 3.5 – Selection criteria for survey 38
Table 3.6 – Classifications of case study interview data (Source: Created for this thesis) 39
Table 3.7 – Identified ethical risks (Source: Created for this thesis) 40
Table 4.1 – Quantizing Level for scaled data (Based on: Miles et al., 2014) 42
Table 4.2: Location of company (Source: Created for this thesis) 47
Table 4.3: Industry Sector (Source: Created for this thesis) 48
Table 4.4: Location of company (Source: Created for this thesis) 48
Table 4.5: Most important success element for supply chain relationships 49
(Source: Created for this thesis) 49
Table 4.6: Second most important success element for supply chain relationships 49
(Source: Created for this thesis) 49
Table 4.7: Most important element for establishing trust in supply chain relationships 50
(Source: Created for this thesis) 50
Table 4.8: The biggest benefit from establishing trust in supply chain relationships (Source: Created for this thesis) 50
Table 4.9: Companies that have trust issues in supply chain relationships 51
(Source: Created for this thesis) 51
Table 4.10: Level of understanding about blockchain (Source: Created for this thesis) 52
Table 4.11: Length of time known about blockchain (Source: Created for this thesis) 53
Table 4.12: Seek information vs Introduced to blockchain (Source: Created for this thesis). 53
Table 4.13: Level of understanding between blockchain and bitcoin (Source: Created for this thesis) 53

Table 4.14: Blockchain Consideration in Company (Source: Created for this thesis)............ 54
Table 4.15: Blockchain Go Live Yet? (Source: Created for this thesis) 54
Table 4.16: Blockchain Inhibitors in the Process (Source: Created for this thesis)................ 54
Table 4.17: Blockchain Decision to Not Go Live/Go Live Yet (Source: Created for this thesis) 54
Table 4.18: Blockchain Areas in the Future (Source: Created for this thesis) 55

1. Introduction

The high level of stakeholder interdependency in supply chain relationships makes trust critical to the overall success of most enterprises (La Londe, 2002). With a greater need for efficiency and competitive advantage, firms with a high level of innovation constantly look for new ways to future proof their supply chain. Further globalisation of industries and economies dictate that, in the future, a digital global currency is plausible. Blockchain could answer an intricate problem: trust without a centralised authority (The Economist, 2015).

1.1 Background

Futurists have concluded that blockchain has the potential to be bigger than the internet. The Centres for Disease Control and Prevention (CDC) wants to use blockchain as a “Weapon Against Deadly Epidemics”. The Japanese Government have legally recognised 11 cryptocurrencies. The Chinese Government have just banned cryptocurrency’s answer to an Initial Public Offering (IPO), the Initial Coin Offering (ICO). Underlying motivation is presumably a lack of sovereign control. It is highly conceivable that blockchain will change the way we interact, the way we buy and sell, the way we trust.

1.2 Research Questions and Objective

This research thesis is exploratory in nature and will provide data to highlight use cases for blockchain and most importantly, how the blockchain architecture could improve trust in the supply chain.

The research seeks to answer the question: how does blockchain affect trust in supply chain relationships?

1.3 Scope and Boundaries of the Research

This research will consider trust found in company’s supplier relationships to establish if there is a need for the improvement of trust. Expanding on this important element, companies that have identified a potential use case for blockchain and are currently undertaking testing will be explored to see if efficiencies and an increase in trust can be found through the use of blockchain technology.

Blockchain is an emerging technology spanning across geographical borders and subsequently having specific regulatory requirements dictated by each country. For this reason, field studies will initially take an ‘etic’ approach. Research will be conducted from New Zealand and Australia with a geographical reach in respondents however, it is important to state that further research should be conducted in the future to ensure ‘imposed etic’ is not inferred from this research thesis due to the varying degree on technology adoption across developed and developing nations (Ghauri & Gronhaug, 2002). Through a series of semi-structured interviews in the second stage of the research, each sponsor will have considered blockchain in their supply chain, either deciding to continue with further testing or alternatively, have failed to proceed further than testing stage. This secondary data that forms insight into the projects, will establish why they chose to test blockchain and what they have concluded regarding increased trust and other added value.

1.4 Importance of the Research

This research seeks to highlight the varying levels of trust in a typical supply chain. It also considers what key attributes should be considered before using blockchain as a trust enabler:

- The research details current expectations of trust and perceivable expectations of stakeholders in a future supply chain.
- The research examines blockchain as a potential enabler of trust in a future supply chain.
- The exploratory research will allow enterprise stakeholders to be further informed of blockchain technology and its current limitations.

1.5 Flow and Contents of Remaining Chapters

The succeeding chapters of this report explore existing academic literature surrounding trust, innovativeness, technology and blockchain in supply chain relationships. It also provides a brief explanation of blockchain and the qualities that differentiate it from similar technologies.

After identifying when an enterprise might use blockchain, a conceptual model is presented to classify why blockchain implementation should be considered. Following this, a thorough research philosophy and methodology is presented in addition to a critical review of the chosen research methodology. The research findings are then presented and discussed.

2. Literature Review

2.1 Introduction

Throughout this literature review, a common theme of trust in supply chain relationships, innovation using technology including blockchain prevails. Blockchain technology will be thoroughly defined within the literature review but as a brief description, Garzik & Donnelly (2017) define blockchain as "distributed, immutable databases that are technological infrastructure". The literature review identifies where a tool to increase trust is required. The appropriate level of innovativeness in a company is then uncovered if blockchain could be considered as a trust enabler in supply chain relationships.

2.2 Definitions of Trust

Trust is a range of observable behaviour and a cognitive state that encompasses predictability (Ireland & Webb, 2007). Simplistically, trust grows by nature based on repetition of trustworthy acts and instils higher levels of trust over time. Trust, by nature, is a complex phenomenon and interpreted differently across cultures, applied differently based on the dynamics of partners and involves a level of psychological processing that cannot always be explained (Fawcett, Jones, Fawcett, 2012)

Psychological in nature., academic literature commonly refers to Rotter's (1967) definition of trust as innate in nature and the expectancy that the trustee's spoken word is dependable. In the opinion offered by Grandison & Sloman (2000) however, consensus has not yet been formed by academics to accurately define trust across multiple contexts and disciplines. It is however widely understood that trust, as a broad topic relates to honesty, competency, reliability and truth (Grandison & Sloman, 2000). Trust, in an organisational construct relies similarly upon these core intrinsic values. That is, goodwill, capability and honesty (Schoorman, Mayer & Davis, 2007), and is built, managed and monitored to ensure supply as per the mutual agreement (Fachrunnisa & Hussain, 2013). Wicks, Berman & Jones (1999) concede that 'optimal trust', based on Aristotle's "virtuous person", is the balance of who to trust and the amount of trust to place on them. Context, social structures, social norms and associated risk all form part of the establishment of trust (Wicks et al., 1999).

Arguably, one of the most notable definitions of trust was Deutsch's extreme position in 1958 when working at Bell Telephone Laboratories. He and colleagues conducted a social experiment to test trust to which they then argue that a players future loss must outweigh the future gain for trust to exist (Deutsch, 1958). Succeeding authors expand this definition to see this trust expectation in reverse, where a participant's future gain is greater than future loss for trust to exist as highlighted in Figure 2.1.

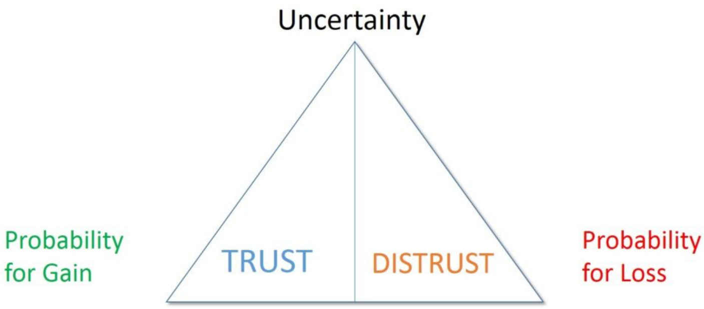

Figure 2.1: Dynamics of trust in today's changing supply chain environment (Fawcett, et al., 2012)

2.2.1 Comparative Definitions of Trust

As presented in Table 2. 1, the various definitions of trust across research disciplines shows that trust can be grouped into eight conceptual paradigms as discussed below.

Table 2.1: The eight conceptual paradigms of trust (Source: Handfield, 2003)

Conceptual Paradigm	Definition
1. Reliability.	Time and experience are critical elements in evaluating trust.
2. Competence.	Experience and wisdom displayed by partner.
3. Goodwill. (a) (openness). (b) (benevolence).	Confidence you can share information or problems with the other party. Accepted duty to protect the rights of your partner.
4. Vulnerability.	Being unprotected or exposed while including an element of uncertainty or risk.
5. Loyalty.	A partner is not just reliable but performs well in extraordinary situations.
6. Multiple Forms of Trust.	There is more than one type of trust.
7. Combining trust with vulnerability.	Cognition and affect-based trust are combined with vulnerability.
8. The future of trust (non-partisan proactive-based trust).	Trust is the primary attention to your own trustworthiness and secondary attention to your partner's trustworthiness.

In paradigm one, Handfield (2003) argues that human nature has elements of predictability and reliability in each stakeholder. It is important to note that reliability does not constitute predictability. Reliability looks to previous actions and conduct whereas predictability includes other elements in addition to reliability to form probable outcomes based on the various inputs. Therefore, when a certain threshold of predictability is crossed, a stakeholder is ultimately trusted. The second paradigm posits that the perceived presence of competency adds to the level of trust. The third paradigm plays again on human nature in that it is in our nature that we display goodwill when another party is willing to be open with confidential elements and protecting your business partner is the right thing to do. The fourth paradigm that trust brings a level of exposure when trust is introduced. Paradigm number five implies that when a partner goes above and beyond, loyalty is earnt, and trust is increased. The sixth conceptual paradigm appreciates that various types and levels of trust exists in combination with each other. Paradigms seven and eight combine causal elements and innate human trust.

2.2.2 Supply Chain Trust and its Role in Supply Chains

Trust is a function of effective supply chain relationships. Laeequddin, Sahay, B.S., Sahay, V., & Abdhul Waheed (2010) described the three key perspectives in establishing and maintaining trust in supply chain relationships as, "…characteristics trust, rational trust, and institutional trust/security system". Expanding on the social concept of characteristic trust, rational trust includes the calculation of the expected gains versus cost, the competencies of the party offering the product or service and technological aspects that influence the outcomes (Laeequddin et al., 2010).

More than ever, companies are competing on the strength of their supply chains (Wicks et al., 1999) and accordingly, the strength of the relationships in both upstream and downstream stakeholders. The establishment and management of trust in supply chain partnerships therefore provides a critical element for competitive advantage and ultimate success (Tejpal, Garg & Sachdeva, 2013). Given the varying types of relationships in a supply chain and subsequent elements of risk associated with each relationship, uncertainty is a key focus when considering whom to trust and when to trust them (Tejpal et al., 2013). Therefore, the hope that trust will be established is undoubtedly a significant consideration in the selection process and formation of partnerships in the supply chain (Fachrunnisa & Hussain, 2013).

The establishment of a strategic partnership in a dyadic relationship, such as a buyer-supplier, is generally decided by executive level management or a procurement team. However, with an increased focus on technology to find process efficiencies, an expert decision maker (stakeholder with a high-level of knowledge) in Information Technology (IT) is required to assess if a partner's product or service meets the needs of the enterprise's security policy (Hutton & Klein, 1999).

It is widely accepted by supply chain professionals that the foundations of Supply Chain Management (SCM) are built upon the flow of materials, products and information (Mentzer, 2004). Strategic decisions are based on the level of uncertainty in this flow. In a traditional logistics model where there is an exchange of goods or services, payment may be requested before services or product is supplied. As trust is established between partners, trading terms may be granted based on a higher level of trust. In the case of service, access to data or systems may be required. This considers trust in a form of information flow and the amount of information that is shared with partners. As described, the level of access to information has a direct correlation to the level of trust (Grandison & Sloman, 2000).

With increased pressure for cost reduction and value added activities in the supply chain (Christopher & Gattorna, 2005), information is increasingly shared digitally. It can be argued that trust, in a digital or technological ecosystem, introduces a different list of criteria to both assess new trust based relationships and the ongoing management and assessment of the relationship. Fachrunnisa & Hussain (2013) describe this digital ecosystem as the combination of “intelligent agents” that source or provide services to each other. In its current state, technology is viewed as an enabler to facilitate an outcome to a transaction, process, or interaction. In turn, the authorising and subsequent authentication of these elements involve another form of trust described above as a security system (Grandison & Sloman, 2000). This distinct trust type is particularly relevant when a company turns to innovation in an effort towards increased efficiencies.

While the various academic definitions of trust have been covered in the previous chapter, in practice the expectations around trust in a supply chain can vary greatly. Trust is evolutionary in supply chain relationships both evolving positively and declining. It often needs to rebuild through restoring and is the building block for parties in the supply chain to collaborate and transact. Trust may present innately, be learnt behaviour through coaching and/or experience and must exist at individual, team, leadership, organisational and inter-organisational levels. Given this importance of trust as an enabler across all hierarchies, it is evident that trust plays a strategically important role in effective and efficient supply chains (Hausman & Johnston, 2010).

2.2.3 Importance of Trust in Supply Chains

Trust emerges as a multidimensional concept embracing several components, such as fairness, loyalty, vulnerability, dependability, non-opportunism, benevolence, and collaboration (Seppanen, Forsman, Monkkonen, Thomson, 2007). Supply chain scholars have largely adopted the categorization of trust advanced by Sako and Helper (1998) who distinguished between contractual, competence, and goodwill trust (Ireland & Webb, 2007). Contractual trust occurs when partners expect that their counterparts will adhere to contractual clauses. Competence trust arises when partners believe that their counterparts possess the needed capabilities for performing specific tasks (Burchell & Wilkinson, 1997). Goodwill trust occurs when partners make open-ended commitments to take initiatives for mutual benefit while refraining from taking unfair advantage of their counterparts. Goodwill trust is the strongest form of trust and is developed through repeated exchanges in long-term relationships.

A significant benefit of the presence of trust in a supply chain is that participants generally behave altruistically in their actions for the better of the entire supply chain even when a negative benefit may occur locally (Capaldo & Giannoccaro, 2015). Inversely, the absence of trust can lead to local negative benefit through a lack of collaboration. This is generally solved by partners agreeing to collaborate to enhance the overall supply chain to not negatively affect the local element.

From a relational exchange perspective, trust is critical to fostering and maintaining interorganizational relationships. Moreover, trust increases the probability for partnered organizations to exchange information and knowledge resources, to be involved in joint learning processes, and to share the costs of discovering and exploiting new opportunities with significant effects on perform (Capaldo, 2007; Nahapiet & Ghoshal, 2017; Paulraj, Lado & Chen, 2008). Figure 2.2. highlights the various stages of trust.

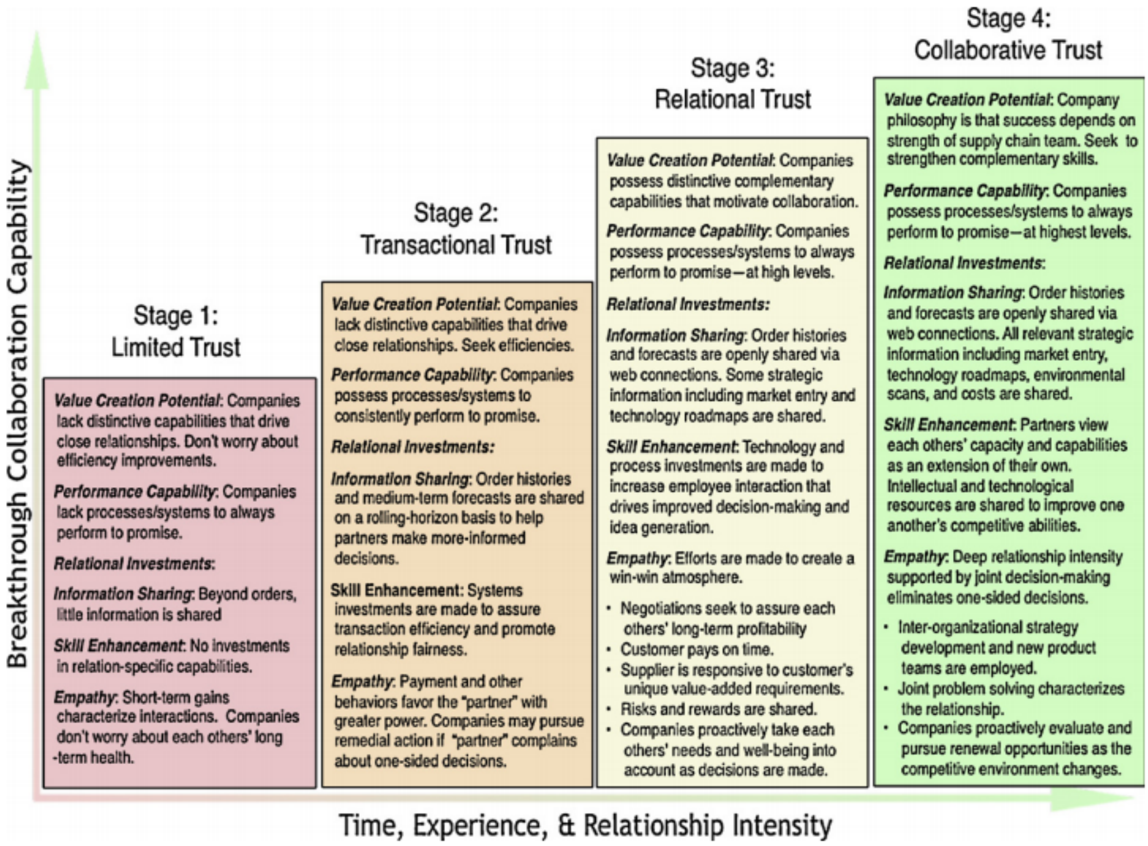

Figure 2.2: Stages of Trust development along time, experience and relationship (Fawcett, et al., 2012)

2.2.4 Trust in Strategic Management

In strategic management studies, trust has been recognized as a determinant of successful interorganizational relationships and associated with both improved adaptability and strategic flexibility as well as with enhanced predictability of partners' behaviour (Mohr & Spekman, 1994) (Yang & Lim, 2009). Accordingly, supply chain scholars have argued that trust is a significant predictor of positive performance outcomes such as improved flexibility, responsiveness, and cost reduction (Handfield & Bechtel, 2002) (Ireland & Webb, 2007) (Narasimhan & Nair, 2005). In fact, trust stimulates partners to collaborate more intensively (Badcock & Gambetta, 1990) and to engage in risk-taking initiatives (Mayer, Davis, & Schoorman, 1995). Figure 2.3 below shows the performance capability and commitment capability matrix in consideration to various paradigms of trust.

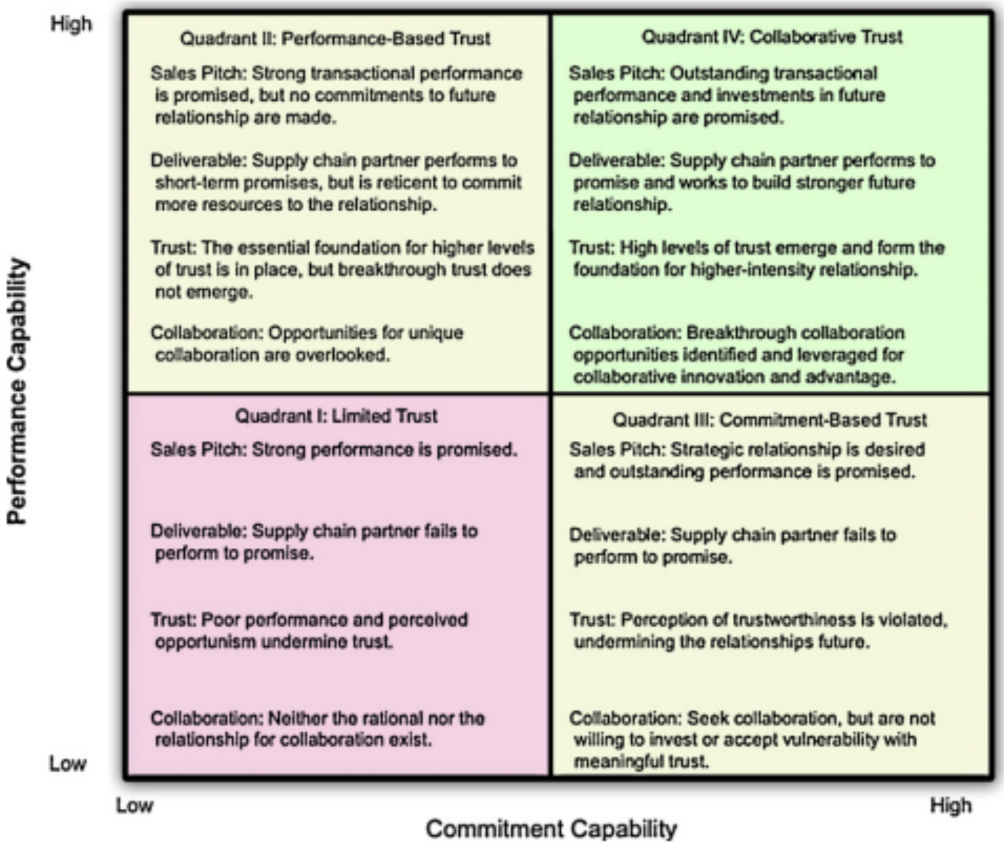

Figure 2.3: Trust, performance and commitment capability matrix Source: (Fawcett, et al., 2012).

2.3 Innovation in a Fast-paced Digital Evolution

Innovation in the supply chain can be initiated from a wide range of actors in the supply chain (Slack, Brandon-Jones, Johnston, & Betts, 2015). Panayides & Venus Lun (2009) cite Zaltman et al's. (1973) definition of innovativeness occurring when a business implements a new process, system, or device. While motivation is not ubiquitous across industries, adoption can include: finding a solution to a problem (Tomas, Hult, Hurley, & Knight, 2004), a firm's level of innovativeness (Hurley & Hult, 1998), cost reduction (T. Y. Choi & Krause, 2006) and competitive advantage in the global supply chain (Mentzer, 2004). Ultimately, innovation can only be sustainable if it benefits the 'triple bottom line': social, environmental and financial (Slack et al., 2015).

Innovation is customarily adopted for advancements in performance of an entity (Damanpour, 1991) and accordingly, has been documented to directly affect an entity's performance (Calantone, Cavusgil, & Zhao, 2002). Adoption alone is not a determining factor of success. How innovation is implemented is justifiably as important (J. N. Choi & Moon, 2013). Choi & Moon (2013) argue that further innovation can materialise in the implementation process. This is particularly poignant with blockchain development. Firica (2017) describes many institutions already finding blockchain success and, as they explore the technology, find more applications that could benefit.

2.4 Supply Chain Trends and Emerging Technologies

In a modern global supply chain, individual business cannot compete independently, rather must act for the mutual benefit of the network in which it is an active participant (Lambert & Cooper, 2000). As such, supply chains are operating under an ever-changing environment and are vulnerable to a myriad of risks at all levels. This environment is an ever-changing landscape because of many factors. Many supply chains extend over wide geographical areas and are vulnerable to global risk (Butner, 2010) and customers are more and more demanding in terms of product customisation, price, and level of service (Christopher, 2011).

Furthermore, the external environment is highly dynamic due to economic (energy cost, prices and availability of raw materials, currency exchange rates), social (unrest and demanding customers) and natural factors (extreme weather conditions, earthquakes, tsunamis, and disease). In recent years, this has never been more pertinent than our current risk factors surrounding Covid-19. With supply chains arguably being the core aspect of any global business model, it becomes essential to keep all supply chain elements running in a smooth manner to ensure on-time delivery of product and service and ultimately achieving customer satisfaction. To keep up with today's challenging and rapidly changing business environment, adapting and incorporating new technology and trends is prudent when considerations of risk and business continuity are at play. One framework for understanding supply chains is the process centric view of the supply chain (Ren, Dong, Ding, Wang & Qiu, 2007; Slack et al., 2015).

If consideration is given to any technological change in the enterprise, it must done in consultation across functional areas with clear outcomes defined including: improved operational efficiency and supply chain visibility (Pagano & Liotine, 2020).

Discussed below are the emerging supply chain technologies and their applications that have the potential to revolutionise the supply chain industry.

2.4.1 Artificial Intelligence (AI)

Artificial Intelligence was introduced to develop and create "thinking machines" that are capable of mimicking, learning, and replacing human intelligence (Min & Zhou, 2002). AI carries great potential to revolutionize supply chain processes. Ultimately focused on managing mundane, repetitive tasks allowing employees to focus on value-add tasks (i.e., solving complex problems, being creative, getting facetime with customers, etc.), AI has quickly gained momentum in supply chain management. AI provides an opportunity to aid and automate complex business decisions and has the potential to revolutionise and cause redundancy to many other emerging technologies (Panetta, 2019).

Artificial intelligence (AI) is becoming more prevalent in supply chain applications (Research and Markets Corporation, 2021). The functionality of AI is using algorithms to create automated procedures based on data from previous processes. This enables companies to create more efficient supply chains through automation and eliminating human error. The other advantage of AI is that it can identify patterns in the supply chain which in turn provides a good understanding of the commodity/product cycles and seasonality (Wins, 2019).

Various forms of AI are being integrated into supply chain management solutions in order "to improve everything from process automation to providing greater visibility into static and real-time data as well as related management information systems" (Research and Markets Corporation, 2021). A mixed method approach combing artificial and human intelligence, AI systems adopt cognitive computing to enhance and automate traditional supply chains (Luger, 2009; Rejeb, Keogh, & Treiblmaier, 2019).

2.4.2 Internet of Things (IoT)

Several interpretations and definitions exist as to what 'Internet of Things' means. Listed below are some interpretations. The first proposition of the term by Kevin Ashton in 1999 painted an enthusiastic picture of the technology "impacting everything" from shop floors to factory worker efficiencies and ultimately achieving both top-line growth and bottom line savings (Tripathy & Anuradha, 2018). Dubbed the third wave of internet, the power of IoT has the potential to network 28 billion items by 2021. It's all encapsulating term is generally regarded as a culmination of the internet and spatially distributed physical devices that are equipped with embedded identification, sensors or actuators (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012). IoT is defined as a smart global network of interconnected devices that utilise underlying web services to communicate and share information (Pal & Yasar, 2021).

Gubbi, Buyya, Marusic, & Palaniswami (2013) describes IoT as the "interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless largescale sensing, data analytics and information representation using cutting edge ubiquitous sensing and cloud computing".

Dorsemaine, Gaulier, Wary, Kheir, & Urien (2016) alternative definition of IoT is "a group of infrastructures interconnecting connected objects and allowing their management, data mining and the access to the data they generate". It forms part of the IT infrastructure whereby transporting, storing, and processing of the data created by both users and the smart devices. The gathered information can be used for effective operational decision making (Pal & Yasar, 2020). IoT brings several capabilities to aid supply chain management, such as cost-saving, inventory accuracy and product tracking (Chopra & Meindl, 2010). IoT based industrial information systems can enhance competitiveness of end-to-end supply chains through more effective tracking of products and data (Shrouf, Ordieres, & Miragliotta, 2014). This is highlighted in Figure 2.4 below.

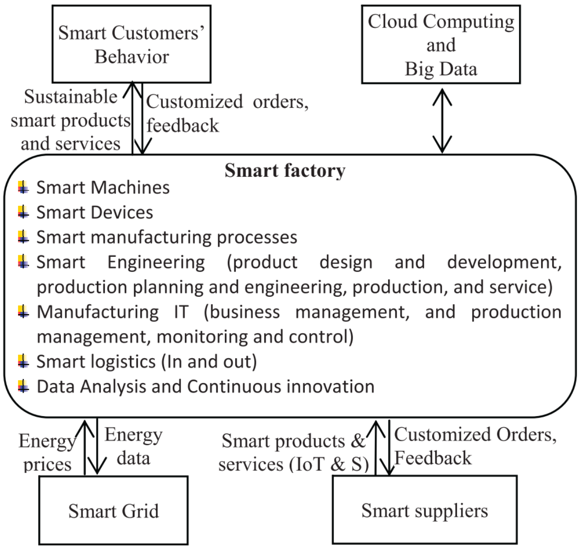

Figure 2.4: Reference architecture for IoT-based smart factory (Source: Shrouf et al., 2014)

Academics and practitioners have identified industrial business processes, particularly regarding supply chain and logistics management as important areas for deploying IoT based information system applications (Atzori, Lera, & Morabito, 2010; Gubbi et al., 2013). In the context of globalized business practice, with multiple collaborating-partner based supply chains, IoT-based applications work to facilitate the sharing of more precise and timely information relevant to production, quality control, distribution and logistics (Rejeb et al., 2019). It has been noted that due to IoT being neoteric technology, consideration of using across a global supply chain does come with security and privacy challenges, particularly concerning standalone IoT applications (Pal & Yasar, 2020).

2.4.3 Robotic Process and Automation (RPA)

RPA is defined as preconfigured software that follows business processes to complete a task or a group of tasks autonomously (Viale & Zouari, 2020). Organisations can deploy 'smart software bots' to automate common operational processes throughout the business, cut costs, eliminate keying errors, speed up processes and link applications. Through RPA, companies can deploy robots leading to the automation of a multitude of back and front office tasks, whereby allowing staff to perform higher value-added tasks.

Anagnoste (2017) discussed that these bots are "intelligent agents" that have the ability to learn tasks that are repetitious, removing errors humans are prone to also removing labour costs. Many organisations use structured data giving them the ability to interpret and process this information through an RPA. By using RPA's, minimum process reengineering is required as it is mimicking the same process as a human.

RPAs are most commonly found where a trigger can be sent to initiate the process. As an example, an email is received, or a document is transmitted to a particular repository. The RPA can then perform Optical Character Recognition (OCR) to extract the information from the file and automatically import it or perform a calculation (e.g., tax calculations, type of document based on a header, etc.). Subsequently, decisions can be made or "triggered" based on predefined conditions. This could include sending a response to the sender to inform them that document did not meet the enterprise's corresponding formatting conditions (Anagnoste, 2017).

It is also becoming more common for companies to use drones and autonomous vehicles in order to streamline logistics functions. Licenses are being issued for drones to be able to perform small goods deliveries to the end user. Autonomous trucks are already utilised in many countries including the USA for long haul operations. TuSimple has a fleet of 40 trucks driving between major cities including a 1,000 mile drive between Phoenix and Dallas (Heilweil, 2020). Expansion is set to continue in both players in the market (including Aurora, Daimler and Embark Trucks) and investment (UPS is a major investor in TuSimple).

Automate Guided Vehicles are becoming increasingly popular in performing warehouse duties (Wins, 2019). Combined with Warehouse Management Systems (WMS), automated robots radically improve productivity. Robots should not be seen as necessarily as replacing humans but often are applied in an integrated approach, particularly when tasks are repetitive or require significant travel time for the warehouse worker. With this adoption, staff can perform higher-value tasks that improve the customer experience.

2.4.4 Big Data Analytics

Big Data Analytics offers a myriad of opportunities to enterprises particularly around the customer journey (Redding & Tjahjono, 2018).

Considered mainstream by both researchers and practitioners, big data adoption has been largely focused on the financial and marketing sectors. It is evident however that big data could play just as crucial role in Supply Chain Management (SCM) (Varela & Tjahjono, 2014). Advanced analytics creates a proactive route for both insight into future opportunities and mitigating future risk (Pettey, 2015).

Advanced analytics, including prescriptive analytics greatly increases firms' ability to make informed decisions, particular in supply chain. Relevant across procurement, transport, demand forecasting and other supply chain areas, data analytics methodically interprets historical data removing a certain level of human error and bias. It is predicted that this area of talent sourcing will be a major of corporations moving forward (Pettey, 2018).

Those corporations that have adopted the use of big data analysis have seen significant gains in transforming their business models and created efficiencies in their supply chains (Varela & Tjahjono, 2014). Many case examples are evident in academic literature in addition to mainstream media highlighting the power of predictive analytics. This includes Amazon's ability to track and trace 1.5 billion inventory items across 200 fulfilment centres globally. Predictive analytics is then utilised to anticipate shipping as to when a customer will inevitably purchase a particular item and ensure it is located at one of its fulfilment centres close to the consumption point (Ritson, 2014).

2.4.5 Industrié 4.0

Sharing commonalities with Smart Factories, Smart Industry, Advanced Manufacturing and Industrial Internet of Things (IIoT), Industrié 4.0 has the potential to revolutionise global production processes (Tjahjono, Esplugues, Ares, & Pelaez, 2017). With focus on its application area of manufacturing, Industrié 4.0 enables digitalisation through the use of, amongst other technologies, advanced robotics, digital fabrication (3D printing) and artificial intelligence (AI). Future manufacturing plants are predicted to harness the power between machines and human workers in Cyber-Physical-Systems (CPSs). With a focus of moving data and processing to the cloud, this technology is not limited to manufacturing and may include delivery and ride services and autonomous vehicles being driven by mixed mode technology including satellite navigation, hi tech sensors and predictive algorithms. Arguably, through partner relationships across the supply chain, expanded value will be added to the customer experience across multiple global geographical areas (Tjahjono, et al., 2017) and allow companies to embrace the fast paced adoption of ecommerce and different customer buying patterns (Brettel, Friederichsen, Keller, Rosenberg, 2014). Perhaps the most revolutionary element of Industrié 4.0 is where smart machines directly communicate to both automate production lines but also to understand and adapt to issues with limited human intervention (Shrouf et al., 2014).

Tjahjono, et al., (2017) states that the term Industrié 4.0, until now, has not yet been conclusively defined, neither are its features. Nonetheless among others there are four main features.

- Vertical networking of smart production systems: this type of networking is based on CPSs to build reconfigurable factories that are flexible and react rapidly to changes in the customer demand. Manufacturing processes in a smart factory enable the true mass customization. It enables "not only autonomous organization of production management but also maintenance management. Resources and products are networked, and materials and parts can be located anywhere and at any time. All processing stages in the production process are logged, with discrepancies registered automatically" (Tjahjono, et al., 2017).

- "Horizontal integration via a new generation of global value chain networks: The implementation of the CPS within the smart factory requires strategies, networks, and business models to accomplish a horizontal integration, which subsequently provides high levels of flexibility, enabling the company to respond faster. The transparency within the value chain allows the manufacturer to identify changes in customer requirements and to reflect them in all of the production steps, from development to distribution" (Tjahjono, et al., 2017).

- "Through-life engineering supports the entire value chain: innovation and technical improvements in engineering are present in the design, development and manufacturing processes. These enable the creation of new products and production systems utilizing a large amount of information (big-data)" (Tjahjono, et al., 2017).

- "Acceleration through exponential technologies: the implementation of innovative technologies enables companies to reduce costs, increase flexibility and customize the product. Industry 4.0 involves automated systems including Artificial Intelligence (AI), robots, drones, nanotechnologies, and a variety of inputs that enable customization, flexibility, and rapid manufacturing" (Tjahjono, et al., 2017).

2.5 Blockchain

While this literature review will now focus on blockchain, it is important to define both blockchain and the cryptocurrency and to understand how they are connected. Garzik & Donnelly (2017) define blockchain as “distributed, immutable databases that are technological infrastructure”. In a similar method, Gaur & Gaiha (2020) describe a blockchain as a “distributed, or decentralized, ledger— a digital system for recording transactions among multiple parties in a verifiable, tamperproof way”. For simplification of this definition, distributed and decentralised ledgers do not require a trusted 3rd party or intermediary to validate each transaction (Bashir, 2017). Blockchain enables a *trustless* network where parties do not need to trust each other in the traditional sense described earlier (Christidis & Devetsikiotis, 2016). To undertake a transaction, a consensus model is used and consists of many computers to agree on the transaction validity (Zhao, Fan, & Yan, 2016) which in turn creates trust in the network.

Figure 2.5 shows the difference between a traditional payment system and a cryptocurrency system such as Bitcoin. It is important to note that not only is there a cost and time reduction, but trust is also administered by the distributed ledger and consensus model rather than a central bank.

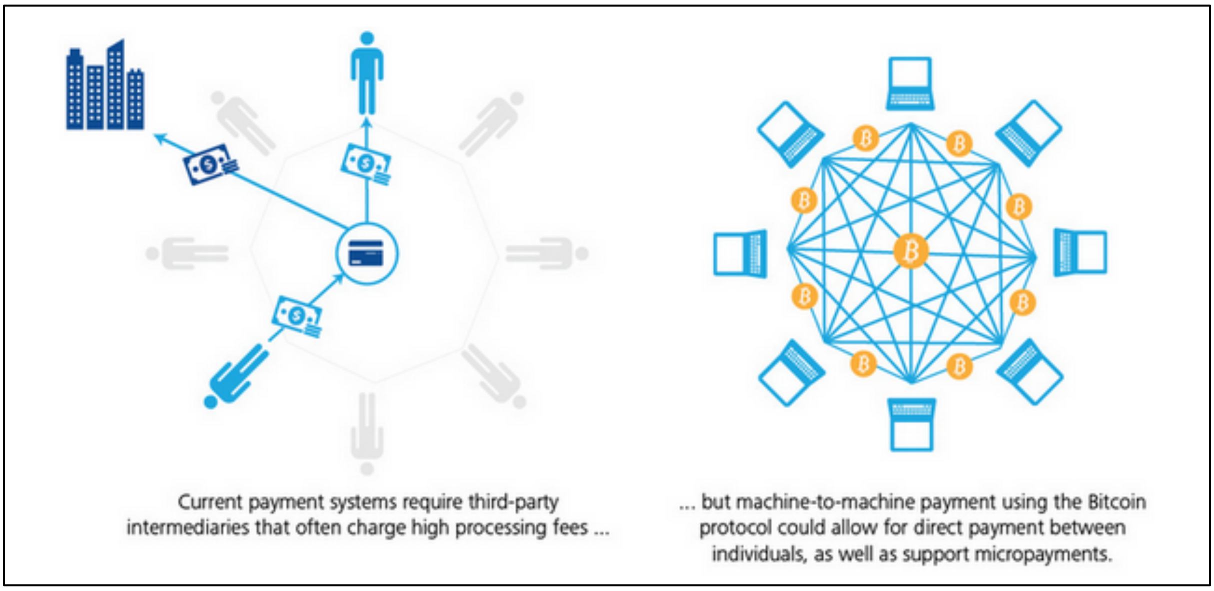

Figure 2.5: Current payment system vs Bitcoin direct payment (Source: Deloitte n.d.)

The second key factor of blockchain is its immutability. Due to the nature of a distributed ledger and the exact information being replicated across many computers, once the transaction has been cryptographically written to the block it is almost impossible to change (Bashir, 2017). The combination of the consensus via a distributed ledger, the transparency created by the ledger being public and the subsequent immutability once the block is written allow for explicitly enforced trust and integrity (Antonopoulos, 2015). The distributed network is represented graphically in Figure 2.6 below.

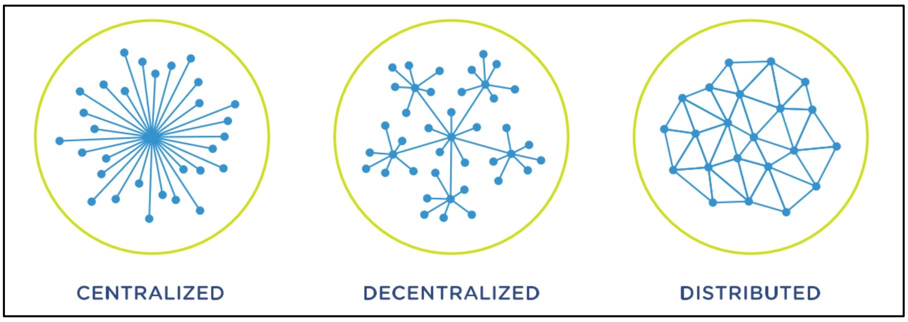

Figure 2.6: The three most common types of networks (Source: Garzik & Donnelly, 2017).

Like a database, the required information of the transaction is written to a ledger. In addition to the user defined information, a timestamp, the 'hash value' of the previous block and a 'nonce' (a random number to validate the hash) are also written. This combination can then be verified back to the first block that was written in the chain. This block is identified as the 'genesis block' (Nofer, Gomber, Hinz, & Schiereck (2017). Figure 2.7 graphically illustrates the process of a blockchain transaction.

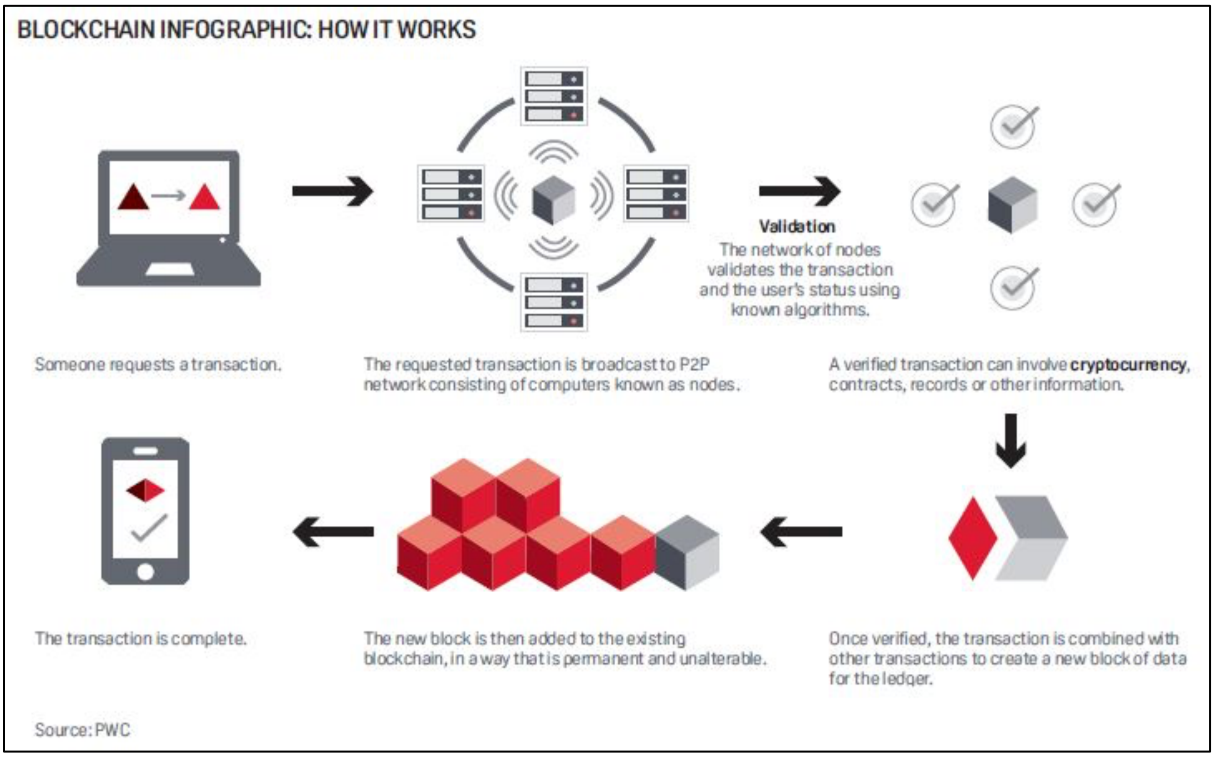

Figure 2.7: Blockchain: How It Works (Source: PwC 2017)

The Bitcoin protocol utilises the power of blockchain and is termed a cryptocurrency or digital currency (Antonopoulos, 2015). While Bitcoin is not the only cryptocurrency to use blockchain technology to facilitate the transaction, it is certainly the most well-known (Yli-Huumo, Ko, Choi, Park, & Smolander, 2016). Bitcoin is not a commodity as it has no intrinsic value like gold. Bitcoin is not yet seen as fiat currency by definition of 'fiat theory' whereby a currency is created by state or sovereign entity (Bjerg, 2016). Bitcoins are completely virtual and are created when a 'miner' (highly powerful computer) solves a particular mathematical problem (Antonopoulos, 2015). The first miner to solve the problem is paid for their service in Bitcoin.

2.5.1 History of Blockchain and Bitcoin

In November 2008, Satoshi Nakamoto (pseudonym) released a white paper titled "Bitcoin: A Peer-to Peer Electronic Cash System". In this paper, Satoshi described how a cryptocurrency system would work in a distributed ledger. Unlike a traditional clearing house or bank, a distributed ledger system no longer requires a centralised source to validate a transaction (Garzik & Donnelly, 2017). Ironically, only two months prior to the paper being made available online (September 15, 2008), the Lehman Brothers filed for bankruptcy in the US. The flow-on effect of the destabilised US economy ensured other economies throughout the world experienced varying negative effects of the global financial crisis (Braude, Eckstein, Fischer, & Flug, 2013). A solution that would decentralise power of the financial system and avoid a future recession was bound to be highly topical. At the time and to some extent, still today, Bitcoin was viewed as highly complex in nature. A combination of the complexity, the anonymity found from Bitcoin and the underworld of the internet's "Dark Net" need for a solution to pay for drugs, guns and other illegal items, Bitcoin became synonymous with cybercrime (Brown, 2016). This is highly unfortunate for blockchain as it and Bitcoin are often seen as one and the same. A brief historical summary of blockchain is captured in Table 2.2 below.

Table 2.2: Blockchain development timeline (Source: Grant Thornton International, 2017; Gupta & Gupta Vinay, 2017)

Year	Blockchain Technology Development
2008	• Satoshi Nakamoto, a pseudonym for a person or group, publishes "Bitcoin: A Peer to Peer Electronic Cash System."
2009	• The first successful Bitcoin (BTC) transaction occurs between computer scientist Hal Finney and the mysterious Satoshi Nakamoto.
2010	• Florida-based programmer Laszlo Hanycez completes the first ever purchase using Bitcoin — two Papa John's pizzas. Hanycez transferred 10,000 BTC's, worth about \$60 at the time. Today it's worth \$80 million. • The market cap of Bitcoin officially exceeds \$1 million.
2011	• 1 BTC = \$1USD, giving the cryptocurrency parity with the US dollar. • Electronic Frontier Foundation, Wikileaks and other organizations start accepting Bitcoin as donations.
2012	• Blockchain and cryptocurrency are mentioned in popular television shows like *The Good Wife*, injecting blockchain into pop culture. • *Bitcoin Magazine* launched by early Bitcoin developer Vitalik Buterin.
2013	• BTC market cap surpassed \$1 billion. • Bitcoin reached \$100/BTC for first time. • Buterin publishes "Ethereum Project" paper suggesting that blockchain has other possibilities besides Bitcoin (e.g., smart contracts).
2014	• Gaming company Zynga, The D Las Vegas Hotel and Overstock.com all start accepting Bitcoin as payment. • Buterin's Ethereum Project is crowdfunded via an Initial Coin Offering (ICO) raising over \$18 million in BTC and opening up new avenues for blockchain. • R3, a group of over 200 blockchain firms, is formed to discover new ways blockchain can be implemented in technology. • PayPal announces Bitcoin integration.

2015	• Number of merchants accepting BTC exceeds 100,000. • NASDAQ and San-Francisco blockchain company Chain team up to test the technology for trading shares in private companies.
2016	• Tech giant IBM announces a blockchain strategy for cloud-based business solutions. • Government of Japan recognizes the legitimacy of blockchain and cryptocurrencies.
2017	• Bitcoin reaches $1,000/BTC for first time. • Cryptocurrency market cap reaches $150 billion. • JP Morgan CEO Jamie Dimon says he believes in blockchain as a future technology, giving the ledger system a vote-of-confidence from Wall Street. • Bitcoin reaches its all-time high at $19,783.21/BTC. • Dubai announces its government will be blockchain-powered by 2020.
2018	• Facebook commits to starting a blockchain group and also hints at the possibility of creating its own cryptocurrency. • IBM develops a blockchain-based banking platform with large banks like Citi and Barclays signing on.

2.5.2 Blockchain Research, Development and Implementation

Blockchain is set to change existing methods of doing business (Bashir, 2017). "The blockchain disrupts and redefines our commonly accepted beliefs around trust" (Mougayar & Buterin, 2016). Due to blockchain being a nascent technology use cases are still emerging (Morabito, 2017). However, many industries are currently testing and exploring opportunities to disrupt. Appendix A tables some of the current projects.

The finance sector is a particularly dominant player in blockchain testing. Their research is to determine if their inefficient processes can be improved and costs can be reduced (Nofer et al., 2017). Using current technology, that is available to consumers, will generally require a bank or similar third party to facilitate the transaction of money between parties (Yli-Huumo et al., 2016). With blockchain, financial transactions can be performed directly between the business or consumer parties which reduces fees and time of processing.

The 2013 Bangladesh garment factory collapse is still raising questions about the ethics of many supply chains. The type of conditions that workers were subjected to are not an isolated incident. Apple's supplier Foxconn is another company under a similar spotlight for employee rights and welfare (Sin, 2016). This unwanted publicity to multi-national companies has brought positive changes for better transparency and ethics in their supplier chains. Provenance (www.provenance.org) is working with retailers and producers in the food and beverage industry to help prove provenance of their product. Consumers can be better informed regarding the company's use of pesticides and food subject that is subject to contamination. In addition to this transparency, worker conditions, pay rates and sustainable practices are also available.

Smart contracts are defined by Bridgers (2017) as "computer code developed to facilitate, verify, monitor, execute, and enforce the terms of an agreement". The point of difference between smart contracts that utilise blockchain and traditional smart contracts is that the events written in the contract can occur with little or no human intervention (Bridgers, 2017). Smart contracts are not limited to any particular industry and could create automated changes in ownership for various trading including title of goods and payment.

For a blockchain application to be a success, enterprises will require new permissioned blockchains, standardisation of the various forms of transactions on each block and strict governance which are currently being developed and implemented (Wins, 2019). Since 1990s, brand names including Procter & Gamble and Walmart have shown considerable advancement in digitising of information share across their supply chains' ERP systems. This increased visibility is still however a challenge for many large supply chains that involve complex transactions (Gaur & Gaiha, 2020). Questions therefore remain on how we can and should create that visibility within the supply chain along with what platform to use.

A popular blockchain protocol called Ethereum allows developers to create and publish applications within their platform. Known as DApps (Decentralised Applications), many hundreds of application already exist including gambling, financial exchanges and social media platforms (Butner, 2010). Like Bitcoin, Ethereum has its own cryptocurrency called Ether and can be both transferred between other players or used to pay fees related to computational power that is used to execute smart contracts. Blockchain is arguably the most well-known cryptocurrency however and has gained mainstream attention, notably due to its rollercoaster price in the market (Lee, 2019).

A blockchain-based supply chain is promising and reliable in traceability and authentication, even eliminating middleman auditors. As proposed by Kshetri (2018), one of the first possible functionalities is to apply blockchain to track all actions in the supply chain such as who is performing the actions, at what time, and where the location of each action occurred. Every authenticated partner in the supply chain can track products, shipments, deliveries, and progress. They can also easily measure the performance of each activity in the supply chain and monitor the quality of products during transportation (Chen, Shi R., Ren, Yan, Shi Y., Zhang, 2017). Therefore, a blockchain-based supply chain reduces the workload and ensures traceability while increasing efficiency, reducing cost, and securing more confidence that the products are genuine and of high quality (Kshetri, 2018). Of course, the applications and usability of blockchain in supply chains are increasing consistently with the support of the Internet of Things (IoTs) and machines providing operational data automatically (Francisco & Swanson, 2018).

2.5.3 Enhancing Traceability

Similar to medicinal traceability initiatives implemented by the *Australia New Zealand Therapeutic Products Agency* (Therapeutic Goods Administration, 2020), The U.S. Drug Supply Chain Security Act of 2013 stipulates all pharmaceutical companies to identify and trace prescription drugs in order to protect consumers from counterfeit, stolen, or harmful products (U.S. Food & Drug Administration, 2014).

Driven by this traceability requirement, a large US pharmaceutical company is collaborating with business partners in its supply chain network to explore blockchain as a solution. Equipped with the global standards association, GS1, inventory is labelled with data matrix codes that are captured as the goods move between trading partners simultaneously being recorded in the blockchain. This process creates a history of all touchpoint events between manufacturer and the end consumer. Early piloting is considered successful and will continue to thoroughly test the blockchain application in other geographical areas (Gaur & Gaiha, 2020). IBM, through its IBM food Trust is also conducting pilots in conjunction with Walmart are using Hyperledger Fabric (another protocol for the blockchain) to trace fresh produce and other food products (IBM Corporate Website, 2019).

A critical element of these application is the reduced sharing of information to the same blockchain. This includes sensitive data that is not shared outside the business including pricing information and payments (Gaur & Gaiha, 2020). This barrier to adoption entices companies to participate in the technology where the benefits outweigh the risk. This increased traceability allows companies to trace faulty or contaminated products right back to the source and triggers an efficient recall (Francisco & Swanson, 2018). Regarding perishable products (including fresh produce and medication), blockchain allows each participant to constantly monitor quality including that of temperature, tampering and other exposure to the elements. Combined with IoT, devices can monitor temperature and automatically record any fluctuations the shipment may encounter. Proof of Provenance can also aid reverse logistics.

2.5.4 A Counterfeit Can be Traced to its Source Using the Blockchain Trail

Where a retailer has concerns around the authenticity of a product, counterfeit products would lack a verification history on the blockchain. A current use case is seen by *Provenance Proof Blockchain* where traceability is applied to coloured gemstones. The entire chain of custody is tracked through every miner, dealer, cutter, treater, gem lab and jeweller can register and add data related to their role (Provenance Proof Blockchain Corporate Website, 2021). Everledger, a UK based firm is also attempting a similar provenance project with "blood diamonds". Diamonds mined in western and central Africa are often used to fund militia groups and their fight against local government (Felin & Lakhani, 2018). With an estimated $2 billion USD in jewellery fraud, Everledger has used blockchain to track and verify a range of luxury goods including diamonds to ensure customers are satisfied with the source and quality of goods.

2.5.5 Increasing Efficiency and Speed and Reducing Disruptions

Emerson, a multinational manufacturing, and engineering company, has a complex supply chain. Thousands of parts across a multitude of suppliers, customers and locations ensures that their supply chain is both unpredictable and lacks visibility. Small delays or disruptions can cause both excess inventory or stock-outs across other parts. According to the president of Emerson, their company is believed to be a perfect candidate for blockchain.

> *A simple illustration of the problem and how blockchain could address it. Consider product A, which uses components C1 and C2, and product B, which uses components C1 and C3. If the manufacture of product B is held up because of a disruption in the production of component C3, the optimal move is to temporarily allocate inventory of C1 to product A until the disruption is resolved. However, if all products and components are manufactured by different companies with limited visibility into one another's inventory, what could easily happen is that excess inventory of C1 piles up at*

the company making product B even if the maker of product A has a stock-out of C1. One solution is for the companies in question to agree to centralize their data on production and inventory-allocation decisions in a common repository. The level of integration that would entail: all involved companies would have to trust others with their data and accept centralized decisions regardless of whether they are partners or competitors is significant (Gaur & Gaiha, 2020).

A more practical solution is for participating companies to share their inventory flows on a blockchain and allow each company to make its own decisions, using common, complete information (Hughes, Dwivedi, Misra, Rana, Raghavan, Akella, 2019). Both financial and retail companies are undertaking pilot programs to connect inventory, complimentary information, and financial flows to applicable parties in their supply chains. The blockchain allows reconciliation of transactional documents including invoices, purchase orders and payments. On receipt of a customer order, the bank is alerted via the blockchain and can immediately provide the company working capital and upon receipt of the product to the buyer, the bank can obtain payment (Gaur & Gaiha, 2020).

The other area of opportunity is cross-border trade, which involves manual processes, physical documents, many intermediaries and multiple checks and verifications at ports of entry and exit. Transactions are slow, costly, and plagued by low visibility into the status of shipments (Hughes, et al., 2019).

2.6 Advantages of Blockchain Technology

Listed below are advantages of blockchain technology implementation (Drescher, 2017; Hughes et al., 2019):

- Disintermediation - This refers to the reduction in need for intermediaries or 3rd parties within the blockchain process. Traditional centralised processes require humans or additional technology to assure trust, with blockchain. This is built in by default.
- Non-repudiation - This benefit relates to the integrity of the blockchain where parties cannot deny or dispute their additions to the blockchain due to the integrity of the transaction history.
- Automation - The working mechanism of blockchains can replace manual labour tasks if the specific use case utilises automated interactions between parties.
- Streamlined process - Under blockchain, business processes will require more standardised, transparent and streamlined as they are redesigned for the transition from traditional technologies.
- Processing speed - The increased use of automation within blockchain processes when compared to centralised architectures is likely to deliver significant execution speed benefits for specific use cases.
- Cost reduction - The net effect of disintermediation and automation is a reduction in costs for those applications that can take advantage of blockchain technology.
- Trust - Blockchain effectively replaces trust in humans with verification and trust in technology and associated protocols. This is likely to be a significant business change from current working practices. Trust in the integrity of security and payment

processing could evolve into a commodity as blockchain becomes ubiquitous and costs begin to fall.
- Increased technology awareness - This is perhaps a side benefit of implementing blockchain, but via the increased awareness and use of this technology, new applications and new understanding is developed.

2.7 Challenges and Current Limitations of Blockchain Technology

Blockchain has several major challenges to overcome. The global supply chain operates in a complex environment that requires various parties to comply with diverse laws, regulations, and institutions. There are various laws and regulations that include maritime laws and regulations, commercial codes, laws pertaining to ownership and possession in multiple jurisdictions along the shipping routes. Since international businesses operate against the backdrop of these established old laws, customs and institutions that are managed by human beings, implementing blockchain-based solutions can be an extremely complex task (Casey & Wong, 2017).

Implementation of blockchain consists of bringing all relevant parties together which can be a difficult undertaking. Everledger Founder and CEO Leanne Kemp noted that it took about 18 months to negotiate the relationships needed to make the Everledger service possible (Kshetri, 2018).

Regarding blockchain's potential to address fraudulent and manipulative activities, Matt Levine notes that the technology can provide a "robust way to make sure that the signatures are in order, the ownership information is up to date, and the inspections have been done". Regarding its limitations, he notes: "but if you then drill a hole in the container, take out all the teddy bears, and replace them with cocaine, the blockchain won't catch that. The blockchain is about taming all of the virtual attributes of the container, all of the paperwork that accompanies it. But the boundary between the physical and virtual worlds will always be a bit more lawless" (Kshetri, 2018).

2.7.1 Centralised or Decentralised?

A contentious issue when discussing blockchain is centralised vs decentralised (Kshetri, 2018). Given the historical roots of Bitcoin and its open-source nature based on consensus theory, many argue for a decentralised form of blockchain (Francisco & Swanson, 2018). Others, namely corporate led associations, insist that centralised infrastructure with only limited access to a select list of participants. A key area of debate is the increased risk of potential attacks of centralised systems. This relates back to the consensus theory and the principle is more participants, less chance of a lack of consensus (Kshetri, 2018).

2.7.2 Computational Power and Knowledge

A considerable barrier to adopt blockchain is the high degree of computerisation. This is most prominent in developing countries where resources may not be as readily available. When company offices are spread across global borders, it makes the opportunity to adopt harder

(Kshetri, 2018). This may result in major data warehouses needing to be located away from their location of use whereby a potential of data and privacy laws may intervene.

2.8 Supply Chain Trust Through Blockchain

Supply chain management (SCM) is an integrative concept to manage the total flows of a distribution channel (Helo & Szekely, 2005). The supply chain is complex because it includes distributed activities from upstream, which deals with people, physical resources and production processes, to downstream, which covers the whole selling process, i.e. contracts, sales to customers, distribution, and disposal (Tian, 2017). The purpose of the supply chain is to establish a multi-stakeholder collaboration environment through mutual trust, to remove communication barriers and ensure different companies are connected to pursue integration of the entire supply network on a routine basis. Ultimately, related stakeholders in the supply chain can improve overall efficiency and bring greater value and benefits to their business (Kshetri, 2018).

Global supply chains are becoming more and more complex in structure and flow of information (Chen et al., 2017). Without an off the shelf solution to simplify this complexity, many companies have resorted to proprietary systems to ensure business processes and ultimately power continues within their control. This type of centralised solution can often lead to reduced transparency, increased security concerns and validation. Blockchain has the potential to be a disruptor across many industries due to qualities of immutability and its decentralised structure (Scott, Loonam, & Kumar, 2017). Due to the nature of blockchain's immutability, it provides a perfect tool to create an absolute truth in an end-to-end supply chain.

2.9 Conceptual Model

There are many elements to consider how blockchain effects trust and whether blockchain could be a value proposition in supply chain relationships. These include when trust should be initiated, how and when trust should be evaluated and if a company has a willingness to innovate when a new technology such as blockchain is discovered. These macro and micro level considerations require a multi-level conceptual model to identify and assess the level of trust and level of innovativeness (Nasierowski & Arcelus, 2012; Schoorman et al., 2007).

Mayer, et al., (1995) recognised the shortcomings of previous academic discourse in the measurement of trust and designed the 'Proposed Model of Trust" (shown in Figure 2.8). It supports the author of this paper's original conceptual framework to measure the current level of trust in an organisation. The Proposed Model of Trust recognises the interpretivist viewpoint that organisations are based on more than bricks and mortar, rather social phenomena play a crucial part. This is made clear by 'factors of *perceived* trustworthiness'. These factors are open to individual interpretation and are subjective based on context.

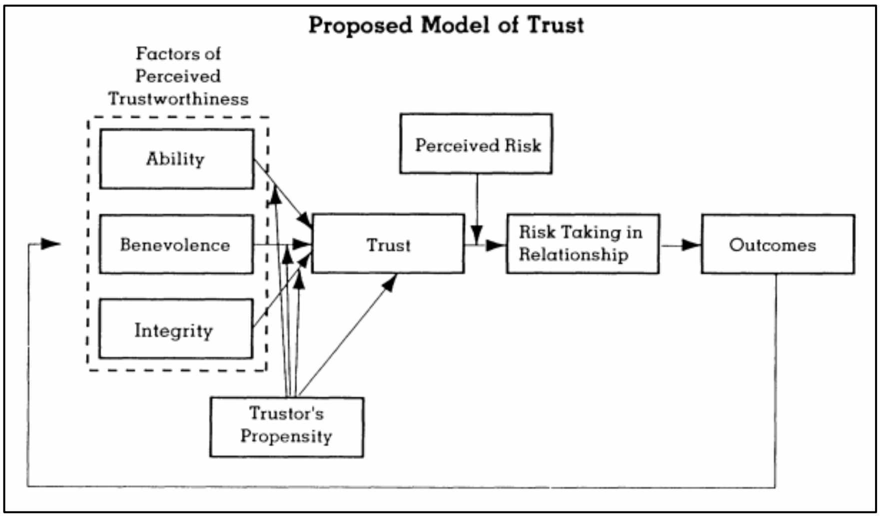

Figure 2.8 – Proposed Model of Trust (Mayer et al., 1995)

Figure 2.9 visually illustrates the author of this paper's original conceptual model to value-add using blockchain in a supply chain. The main constructs are explained as follows:

Transactions
The conceptual model below is centred upon common supply chain transactions. A transaction is a normal activity that occurs between supply chain partners to achieve mutually beneficial outcomes.

Supply Chain Relationships
Supply chain relationships are formed after a successful *selection* process, continued with ongoing *management* and is progressive if a certain *innovation level* is obtained.

Objectives
Supply chain objectives are influenced and achieved by: trust, sustainability, visibility and efficiency.

Variable
Blockchain integration is intended to add security and data validity and consequently aid in the supply chain objectives listed.

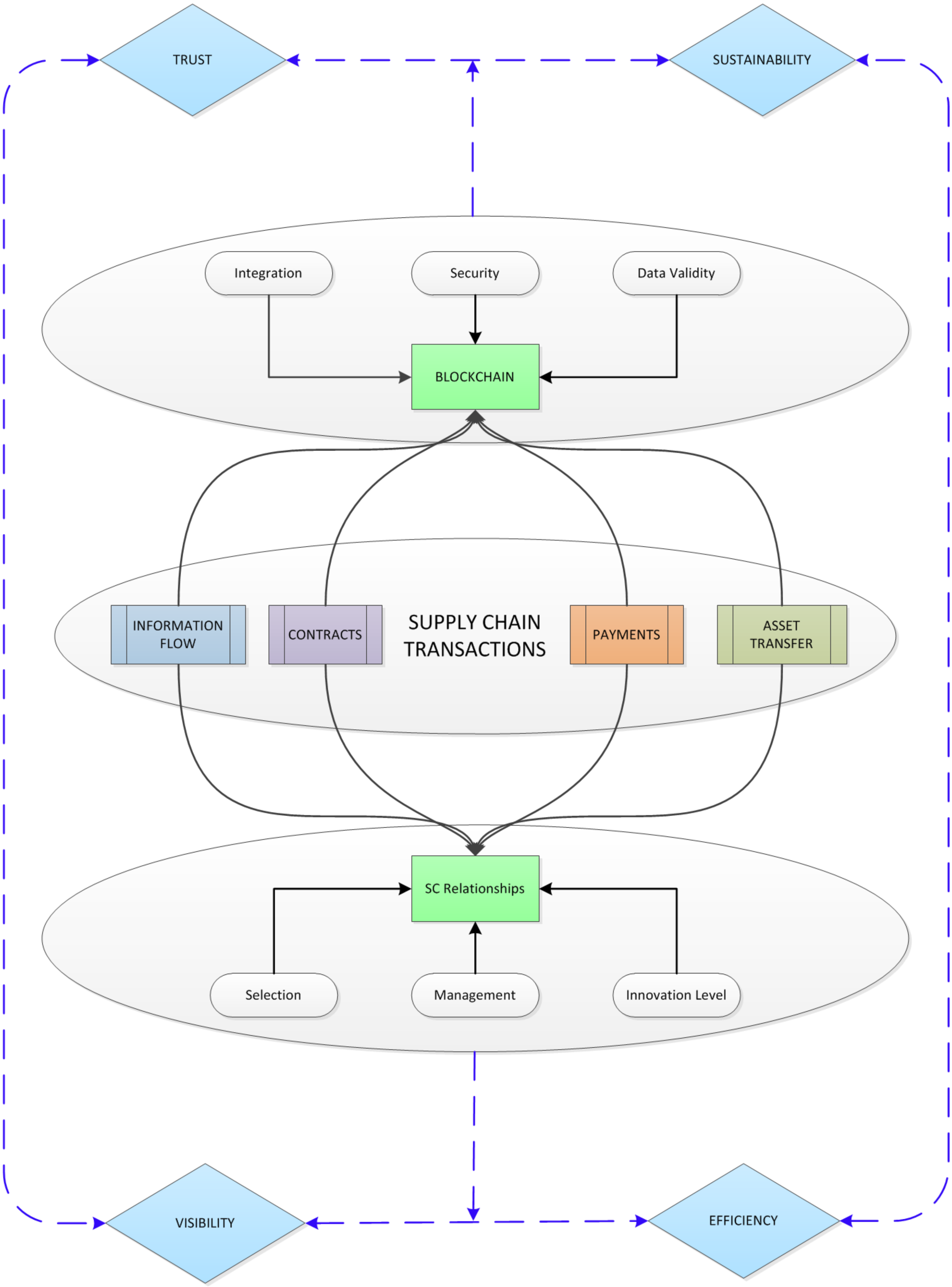

Figure 2.9 – Conceptual model to value-add in the Supply Chain via blockchain (Source: Created for this thesis)

2.10 Summary of Most Important Aspects of Literature

As identified in the conceptual model, the literature emphasises the importance of both the establishment of trust and the subsequent measurement of the trust that has been observed. Trust can be ambiguous; therefore, a clear definition must be established prior to research to ensure consistency across the findings. Laeequddin et al. (2010) identified three types of trust:

- Characteristic trust
- Rational trust
- Institutional trust/security system

More than ever, companies are competing on the strength of their supply chains (Wicks et al., 1999). The strength of relationships in the supply chain result in a competitive advantage (Tejpal et al., 2013). Risk forms part of these strategic decisions to undertake a partnership and consequently, the level of risk must be given weight in the decision process (Tejpal et al., 2013).

Trust is not limited to the decision to trade with a supplier. Trust must also be considered when assessing the amount of information that is shared across the supply chain. Trust and the level of information accessible are directly correlated (Grandison & Sloman, 2000).

Innovativeness is a firm's willingness and capacity to adopt new systems, processes or equipment (Zaltman et al., 1973 cited by Panayides & Venus Lun 2009). Adoption and implementation are equally as important in the determination of success (Calantone et al., 2002; J. N. Choi & Moon, 2013).

Blockchain's immutability provides a perfect tool in creating an absolute truth in an end-to-end supply chain. Blockchain is a nascent technology and accordingly, its usage as a disruptor is still emerging. Many use cases however can already be found across the globe and in many diverse industries. Current iterations of blockchain are providing a tool to allow financial transactions to bypass the bank and communicate digitally directly with the other party.

2.11 Research Gap

Much time has been allowed for academics to define both trust and innovation. The literature has identified numerous conceptual models and frameworks to allow measurement of trust and innovativeness. With both incipient media and industry attention, the blockchain hype is ensuring that academics take notice from a social science research perspective. It is however an immature field of research. Much of the work currently undertaken revolves around specific sectors including financial, healthcare and banking. No published research to date has evaluated if blockchain could be considered as a dominant solution for establishing trust in an end-to-end supply chain. The secondary function of new research would allow documentation of perceived trust benefits for each level of stakeholder: raw materials supplier, manufacturer, distributor, and consumer if blockchain was implemented.

3. Research Methodology

3.1 Detailed Descriptions of Research Question

The research seeks to give valuable insight into applications that may benefit from blockchain as an enabler in providing increased trust in supply chain relationships. After identification of an application that would benefit from the trust acquired through blockchain, a conceptual tool will be documented.

The question proposed is: How does blockchain affect trust in supply chain relationships?

3.2 Research Methods Overview

The author upholds a constructivist ontological viewpoint and an interpretivist epistemological viewpoint. Given this position, research will be approached in the form of qualitative methodology.

Through an initial open-ended survey in addition to semi-structured interviews of select stakeholders within enterprises that have sought to test blockchain in their supply chain, an understanding of key drivers that led to testing will be documented. The advantages and disadvantages identified through literature research for the implementation of blockchain in a supply chain are documented in Table 3.1 below.

Table 3.1 – Advantages and disadvantages identified in supply chain adoption of blockchain (Source: Created for this thesis)

Advantage	Reference	Disadvantage	Reference
Trust	(Herian, 2017)	Lacks human element of innate trust development	(Uuriintuya, 2017)
Transaction Efficiency	(Firica, 2017)	Current interoperability between blockchains	(Underwood, 2016)
Disruptive innovation	(Nofer et al., 2017)	Slow stakeholder adoption	(Beverege, 2017)
Proof of Provenance	(Christidis & Devetsikiotis, 2016)	Current regulation still catching up	(Levin, Waltz, & LaCount, (2018)
Immutable	(Zhao et al., 2016)	Volatility of crypto currency as payment	mid 2015)
Sustainability	Abeyratne & Monfared 2016)	Current speed of transactions	(Drescher, 2017)
Potential of emerging Global Currency	(Samid, 2015)	Large data storage (& associated costs)	(Beverege, 2017)

Smart Contracts	(Kristof, 2017)	Limited expertise in blockchain space	(Iansiti & Lakhani, 2017)
Distributed Ledger (removes central authority)	(Firica, 2017)	Distributed Ledger (removes central authority)	(Firica, 2017)
Visibility	(Abeyratne & Monfared, 2016)		

3.3 Ontological Perspectives

The development of an ontological and subsequent epistemological perspective is the initial step for all research (Grix, 2002). It is critical for a researcher to establish their position on both as it will define their approach to research. Grix (2002) cites Blaikie and defines Ontological claims 'are concerned with what we believe constitutes social reality'. Jonassen (1991) describes objectivism and constructivism and their differentiation based on metaphysical and epistemological principles. Supporting ontological philosophy are two traditional views of how actors see the world: 'objectivism' and 'constructionism'. Objectivism is a position that perceives that all behaviour and underlying meaning is independent of the actors that are involved (Grix, 2002). Constructivism holds the perspective that behaviour is not only produced by the actors involved but is in continual adjustment and correction (Grix, 2002).

This research focuses on two or more actors and the supply chain relationships they share. A supply chain could be perceived as 'real' and align with objectivism or alternatively, a supply chain could be seen to be founded upon exchanges of the parties. In the formulation of my ontological position, I have concluded that trust, at least in its intrinsic sense found in supply chain relationships that I have researched, aligns me to a constructivist's viewpoint. The interaction is developed between actors and is in a constant state of change based on interactions (Grix, 2002).

I am however conscious that the interchanges between actors does have the potential to revert to an objectivist viewpoint when trust is viewed in perspective of blockchain. The truth suddenly becomes black and white as the 'rule book' is defined by the code is absolute and unchangeable (immutable) once written for that transaction or in the case of smart contract, once the trigger has occurred.

3.4 Epistemological Perspectives

Epistemology is defined by the Merriam-Webster Dictionary (Merriam-Webster.com, 2018) as "the study or a theory of the nature and grounds of knowledge especially with reference to its limits and validity" (Merriam-Webster online dictionary). Grix (2002) discusses epistemology's importance in building upon current academic work by gathering new knowledge and constructing new theories and frameworks. The two opposing viewpoints of epistemology are 'positivism' and 'interpretivism'. Positivism believes that the frameworks developed for natural sciences are also valid for the study of society and the actors that form part of it (Bryman cited by Grix 2002). Interpretivism's epistemological position dictates that the strategy must have regard for distinctions between human behaviour and objects in a social capacity (Bryman cited by Grix 2002).

I firmly believe that what we experience, what we evaluate consciously and sub-consciously is open to interpretation based on our personal experiences, culture, and general perspective to knowledge. I note in the supply chain exchanges I have witnessed:

- Trust is interpreted subjectively by the actors when undertaking procurement activities. This is based on previous experiences of the parties involved in negotiating. This would indicate a subjectivist viewpoint and consequently, a constructionist ontology.
- The level of innovativeness in a supply chain is relative to the industry or competitor. If an idea is new for the industry but not for SCM, it would still be considered innovative by the internal actors implementing the innovation. This would again indicate a subjectivist epistemology and constructionist ontology.
- Lastly, based on Burrell and Morgan's four paradigms (cited by Bryman & Bell 2011) and the proposed original conceptual framework in Figure 2.5.3, a 'Radical' paradigm will be taken to assess the current state of the surveyed enterprises, the best practice in industry and the method to achieve the determined shortfalls. This position leads to a further distinction in epistemological approach. That is, the position of a 'functionalist' whereby the focus is geared towards problem-solving leading to a plausible explanation of events (Bryman & Bell, 2011).

3.5 Appraisal of Alternative Research Methodologies

3.5.1 Quantitative and Qualitative Methods

A high-level grouping of research methods provides two classifications: quantitative and qualitative. A simplistic differentiation is offered by Bryman & Bell (2011) that states 'measurement' is used by quantitative researchers whereas qualitative researchers do not. Bryman & Bell (2011) continue to share a belief common to many researchers that concludes quantitative and qualitative methods also have a distinct epistemological viewpoint, consequently, this leads to a different approach to research. Table 3.2 (Bryman & Bell, 2011) shows the key differences between quantitative and qualitative approaches.

Table 3.2: Fundamental Differences between Quantitative and Qualitative Research (Source: Bryman & Bell 2011)

	Quantitative	Qualitative
Principal Orientation to the role of theory in relation to research	Deductive; testing of theory	Inductive; generation of theory
Epistemological orientation	Natural Science model, in particular positivism	Interpretivism
Ontological orientation		Constructionism

As highlighted in Table 3.2, quantitative research applies a deductive approach when considering links between theory and research. It ensures that the researcher does not in any way interact with the subject and is merely an observer (Bryman & Bell, 2011). Contrastingly, by applying an inductive approach, qualitative focuses on sharing the findings through words. Researchers with a constructivist approach to research may also argue that their focus is the creation of new theories (Bryman & Bell, 2011). Constructivists firmly believe that the natural sciences classification system is not applicable when observing social interaction.

3.5.2 Mixed Methods Approach

The third grouping that can be considered in research techniques is a blended approach termed: mixed methods methodology. The underlying idea of using a blended approach is to balance the strengths and weaknesses of the quantitative and qualitative methods (Bryman & Bell, 2011). Scholars cannot however categorically agree with this approach. The two main factors for this argument are: the researcher's ontological and epistemological viewpoint, that is what we know and how we came to this knowledge is remotely different (Grix, 2002). Secondly, the "paradigm argument" that concedes the assumptions we make before starting and in turn, the methods of research we apply are at opposite ends of the spectrum (Bryman & Bell, 2011).

The mixed methods approach has become a preferred method in business and organisational research where the researcher holds a belief that the firm is a combination of both the objects and the interactions that occur within an ever-changing environment (Bryman & Bell, 2011). Evidence concludes that the initial design and the preceding undertaking of mixed methods research is critical to accurate findings (Bryman & Bell, 2011).

Bryman & Bell (2011) cite Zamanou and Glaser's work whereby the study of culture in a US Government Organisation utilised a mixed methods methodology. By applying various techniques including surveys, interviews and observations Zamanou and Glaser triangulated the data. They were then able to validate information across both the quantitative and qualitative findings.

3.6 Selection of Research Methodology

In comparing the three orientations of research in conjunction with my own ontological and epistemological views, I have concluded that the qualitative approach is aligned with my deductive approach to research but as a starting point to ascertain focus areas for interviews, a mixed methods approach with greater focus on qualitative is most suited. That is, to embrace the personalities of actors at each stage of a supply chain, observe their interactions both intra-organisationally and inter-organisationally and find meaning from it. This inductive approach to theory is arguably appropriate given the immaturity of academic research within the blockchain area and a clear idea of problems cannot be accurately detailed (Cooper, D & Schindler, 2008). Table 3.3 synthesises the author's approach to research including relative commentary.

Table 3.3 – Summary of author’s approach to research (Source: Created for this thesis)

Position	Qualitative	Summary
Theory	• Inductive	• Theory will be created from the plausible explanation of outcome
Epistemology	• Interpretivist • Functionalist	• Interpretation is based on previous experiences of parties • Geared towards problem-solving
Ontology	• Constructivist	• Supply chains are founded upon exchanges of parties within them

3.7 Detailed Description of Research Approach

Exploratory in nature, the collection of data will be achieved through an online survey and subsequent semi-structured interviews to ensure the supply chain context is clearly evaluated. Cooper and Schindler (2008) assert case studies will consider more weight to a complete contextual analysis of scenarios and situations and the occurring interactions. They further confer that this depth of analysis brings important insight for solving problems and further evaluation and subsequent development of strategy. Table 3.4 lists key descriptors of research design for consideration. The author’s selected approach to research has been indicated in bold and italics below and specific details in the comment’s column.

Table 3.4 – Descriptors of Research Design (Source: Cooper, & Schindler 2008)

Category	Options	Summary
The degree to which the research question has been crystallised	• ***Exploratory study*** • Formal study	Opportunity to develop concepts and explore the final research design
The method of data collection	• Monitoring • ***Communication***	Through survey questions, the author will collect responses
The power of the researcher to product effects in the variables under study	• Experimental • ***Ex post facto***	Author has little or no control over the variables
The purpose of the study	• Descriptive • ***Causal***	Why did or why didn’t an enterprise pursue blockchain testing?
The time dimension	• ***Cross-sectional*** • Longitudinal	Technology is constantly evolving and snapshot of status quo is appropriate
The topical scope - breadth and depth - of the study	• ***Case*** • Statistical study	Aligning to ‘Functionalist’ epistemology, case studies provide insight for problem solving
The research environment	• ***Field setting*** • Laboratory research • Simulation	Appropriate to industry research involving interviews and surveys
The participants' perceptions of research activity	• ***Actual routine*** • Modified routine	Interviewees are fully aware of the research and will describe their perspective on the enterprise project

Despite theory being generated from research (Bryman, 2012), it is important to formulate a clear process of the events that will occur with the research process. Figure 3.1 below gives a clear visual representation of the main steps involved when a qualitative research methodology is adopted. It is noted by Bryman & Bell (2011) that this is a guide as a starting point and is generally never found this structured in qualitative research.

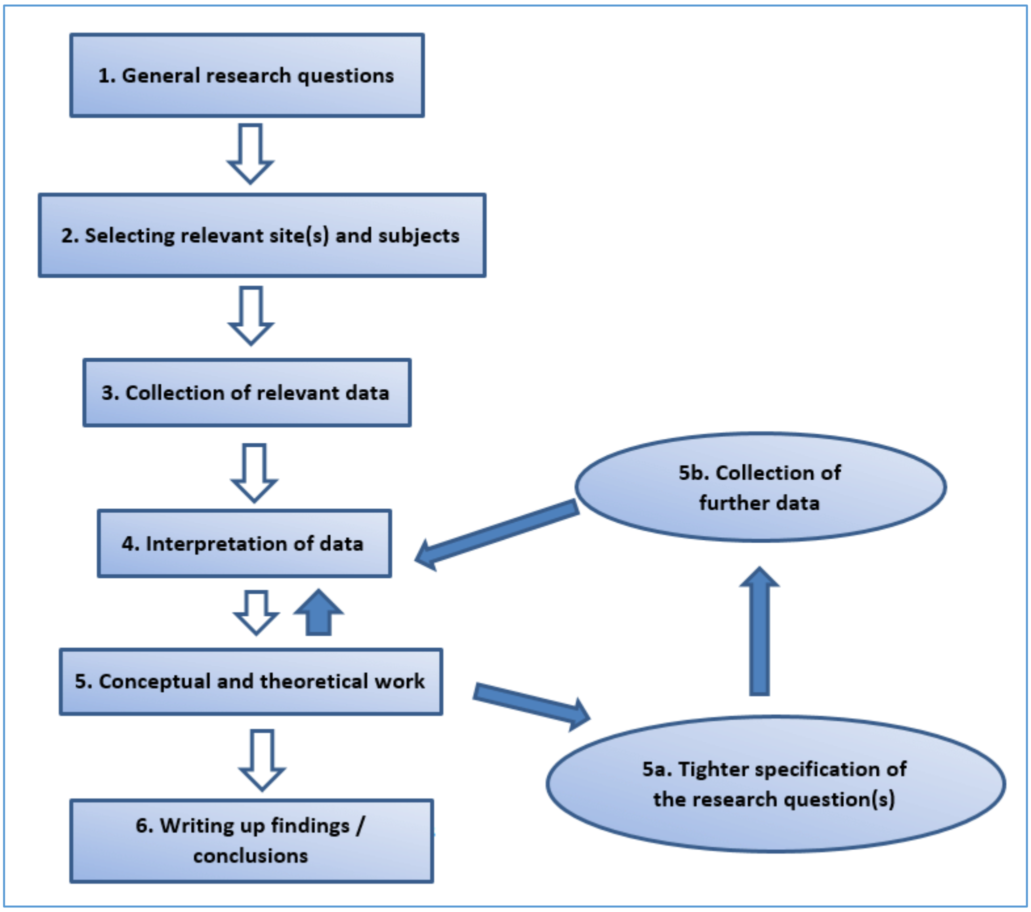

Figure 3.1 – An Outline of the main Steps of Qualitative Research (Source: Bryman 2012)

Stage 1 – Defined as part of the literature review. The research question stems from a greater need for trust and innovation in supply chain relationships.

Stage 2 – Sampling: Enterprises will be selected based on the criteria outlined in Table 3.5.

Table 3.5 – Selection criteria for survey

Criteria	Summary
Focus of supply chain importance	For value to be added, it is critical that an enterprise acknowledges the value that an efficient supply chain adds to the company.
Issues with supply chain relationship trust	This could include: a complex supplier network or a global supply chain that integrates with less known suppliers.
High level of innovativeness	Through the literature research, it was identified that a high level of innovativeness was required for a new process to be adopted successfully.
Testing in blockchain tech	Ideally, both current or previous (failed) testing to accurately document the reasons why further pilots did not proceed.
Enterprise's openness to share information	For accurate data collection, an enterprise must be willing to provide time to meet and share relevant information.

Stage 3 - It is expected that a researcher within an exploratory study conducts initial research of secondary data (Cooper, D & Schindler, 2008). Common themes of trust, innovation, sustainability, and visibility have been widely identified in initial research. Secondary data found within the participating enterprise may evidently hold similar findings. This secondary data is extremely relevant to the research question, that is, what was identified that caused the enterprise to consider blockchain as a potential solution? Preceding analysis of secondary data, 'qualitative interviewing' will be undertaken. Conducted in combination with management and the enterprise's technical team, motivation for the initial interest in blockchain will be explored and tabled. It is expected that as part of the iterative process, the interview questions will be further defined after the survey.

Stage 4,5,6 – As a social researcher, the author is interested in measuring items that often 'cannot be directly observed' (Neuman, 2006). This includes 'attitudes, ideology, divorce rates, deviance, social roles, etc'. Through the process conceptualisation, these items and other relevant identifiers found in the interview will be processed through 'categorical aggregation' to allow for a case study analysis of the data at Stage 5. This representation of the case study is documented in Table 3.6.

Table 3.6 – Classifications of case study interview data (Source: Created for this thesis)

Type of Data	Class/Identifier	Summary
Data on behaviour	• Testing Status	• Keyword identification: Proceeding/Discontinued/Other
Data on intentions	• Other use cases identified in testing phase	• Keyword, phrase, sentence
Data on motivations	• Initial motivators to test blockchain	• Keyword, phrase, sentence
Status and state of affairs	• Sector • Industry	• Keyword identification: Public/Private • Keyword identification. Eg. electronics, food, healthcare
	• Demographic data	• Country, enterprise turnover, level of education, cryptocurrency regulations
	• Stakeholder type (where in supply chain)	• Keyword identification: Raw material sup /Manufacturer/Distributor/Transport
Attitude and opinion	• Senior management support for project	• High/Med/Low
	• Team support for the project	• High/Med/Low
	• Level of innovativeness of other supply chain participants	• High/Med/Low
	• Perceived trust in current supply chain	• High/Med/Low
	• Significant statements	• Keyword, phrase, sentence
	• Advantages and disadvantages identified	• Keyword, phrase, sentence

Awareness and knowledge of data	• Expected costs: development and cost to serve	• $ value
	• Expected savings: transactional and other	• $ value

The above classifications are important to identify recurring concepts in the analysis of data. These concepts will be used to find relationships between the key identifiers that could contribute to supply chain trust. Bryman (2012) suggests that researchers involved in social sciences should appreciate that these concepts are fluid and provide a reference point at the various stages in the research. Conceptualisation in qualitative research is a "work in progress" as constructs are formulated and made sense of as data is collected and analysed (Neuman, 2006). Creswell (2007) describes this process of dividing the data and reassembling to create further insight and allow for patterns between 2 or more classifications. Through synthesising primary and secondary data, the case study analysis will allow the author to operationalise the constructs into a form that can be considered by industry for the application of blockchain.

3.8 Ethical Considerations

Cooper & Schindler (2008) describe ethics as 'norms or standards of behaviour that guide moral choices about our behaviour and our relationships with others'. The primary objective in ethical research is summarised as: not cause harm to any participant, show respect for participants, and ensure cultural and social sensitivity to all involved in the research process. Throughout the research, the author will focus on ethical risk minimisation. Table 3.7 below summarises Cooper, & Schindler (2008) and Massey University's key ethical risks, in particular risks that are particularly relevant to this research topic. A summary of the action taken by the researcher is also provided.

Table 3.7 – Identified ethical risks (Source: Created for this thesis)

Risk	Summary
• Deception	• Participants will be informed of entire 'truth' research.
• Informed and voluntary consent	• Full disclosure of processes and purpose to participant. Oral or written consent will be requested.
• Privacy/confidentiality	• Participant has right to not answer a question asked. • Non-Disclosure Agreement (NDA) for all participants viewing data. Data will only be available to author and supervisor. • Research will restrict identification of participant data as required. • Company's identification will be separated from proprietary information and commercially sensitive data.
• Sponsor nondisclosure • Purpose nondisclosure • Findings nondisclosure	• Option for sponsor to Dissociate from research project. • Option for sponsor to request purpose of their blockchain project in research documentation not be disclosed. • Opportunity for sponsor to 'vet' findings of research before published.
• Conflict of Interest	• Analysis of any power relationship in play between participant and researcher and modify process accordingly to alleviate

4. Analysis

4.1 Introduction

Based on the exploratory scope of this research, it was decided that a survey should be conducted prior to further research to adequately assess and answer the research topic:

- If trust is a perceived issue in supply chains.
- If trust is considered a key element to supplier relationship success.
- If companies are aware of blockchain.
- If they have considered blockchain or are considering it.
- Why they have/have not considered it.

4.2 Data Collection Methods

The target sample size for the survey was 150 global companies. Unfortunately, total respondents totalled 60 only. However, given the nature of the qualitative approach, the 60 respondents were from a good cross-section of major industry sectors where their supply chain is highly depended upon for the company's success.

The survey data was collected via an online survey and shared via email to known industry experts and other targeted industry expert forums such as LinkedIn's supply chain groups. It was a prerequisite that participants met the requirements of the intended outlined below namely:

- The participant should have a good knowledge of their company's supply chain.
- Ideally, knowledge of their IT and applicable systems.

Further to this survey, semi-structured interviews were used to probe further into common themes of why trust was considered an issue, what interventions (including emerging technologies) the company had considered and the consensus on blockchain and its use case in 2020. The common theme of each interview is explored in chapter 5.

4.2.1 Sampling and Criteria Requirement

A sample from the population is broadly considered either *probability sampling* or alternatively, *non-probability sampling* (Bryman, 2016). In the context of this research paper being focused on qualitative methods, *purposive sampling* is the chosen form of sampling. Purposive sampling is best suited when participants are strategically considered based on attributes that are relevant to the research question and research goals (Bryman & Bell, 2019). This report will use a form of *theoretical sampling*. Bryman (2016) describes theoretical strategy as useful when attempting to find categories and their properties, furthermore interrelationships within the concept. Ideally, surveys and interviews would continue under this method until *theoretical saturation* is achieved, particularly given the iterative nature of technology but due to the time limitations of this study, it is not possible for this to occur.

4.2.2 Web Surveys

Web surveys are via invitation by email, social media, sms and other similar means whereby a hyperlink to the survey is sent. Bryman (2016) writes that an advantage over the more traditional embedded or attached email survey is that web surveys allows for greater formatting options but more importantly, can introduce filters or, commonly referred to as 'skip logic' in marketing and research literature (Qualtrics Corporate Website, 2021). The other advantage of web surveys is that the data is collated automatically through the system whereby reducing coding.

4.2.3 Survey Development

Using Google Forms, 30 questions (open-ended wherever possible) were developed to ascertain the participants perceived issues around trust, supplier relationship, emerging technologies and their current level of knowledge and adoption of blockchain (APPENDIX A).

Although not mandatory, participants were encouraged to leave their email for two reasons, to ensure that multiple replies were not received and also to incentivise participants that might want to receive the aggregated data after the report had been completed. Kumar's, (2011) personal reflection is that incentives do not generally increase the participation rate but rather the importance of the study does. Given the target audience were businesspeople with a potentially keen interest in the findings, the receiving of the findings would hypothetically disagree with this opinion.

The first five questions were to allow the research to compare different company profiles and find trends in particular industries, turnover, or regions. This included: number of employees, annual turnover, nation or multi-national and the region. The next two questions were to crosscheck the spread of participants roles within the organisation. The motivation was to gain insight into any trends regarding level of knowledge across any variables regarding emerging technologies.

Questions that sought to answer attitudinal characteristics were assigned ordinal values and an 8-point Likert Scale was then applied. Table 4.1 represents the quantization levels applied to the ordinal values.

Table 4.1 – Quantizing Level for scaled data (Based on: Miles, Huberman, & Saldana, (2014)

Value	Level
7-8	• High/Highly Agree
6	• Moderate-high/Moderately-Highly Agree
4-5	• Moderate/Moderately Agree or Neutral
2-3	• Moderate-low/Disagree
1	• Non-existent-Low/Highly Disagree

4.3 Data Analysis Methods

In the first instance of the mixed methods approach, the data is analysed by SPSS (Statistical Package for the Social Sciences) to generate descriptive statistics and support or dismiss these two hypotheses:

A. H_1: block chain increases trust in the supply chain.
B. H_2: number of employees, annual turnover, being multinational, type of industry, understanding of block chain and location influence trust of block chain in the supply chain.

The process for H_1 involved a logistics regression analysis. The results are found in the next chapter, statistical validation process. When introducing multiple variables in H_2, multiple binary logistic regression was introduced to look for significance between any of the dependant variables. After running this process, it became obvious the importance of checking for multi-collinearity between factors as it would be generally considered that size of company, annual turnover and number of employees would be related. Therefore, backwards binary stepwise logistics regression analysis was chosen to eliminate these factors.

4.4 Statistical Validation Process

Hypotheses:

A. H_1: blockchain increases trust in the supply chain
B. H_2: number of employees, annual turnover, being multinational, type of industry, understanding of block chain and location influence trust of block chain in the supply chain

Methodology for H_1:
Let π be the proportion of firms that believe block chain increases trust in the supply chain.
Test that $\pi > 0.5$
Test statistic: $Z_p = \frac{p-\pi}{\sqrt{\pi \times \alpha / n}}$
Decision rule: $\alpha = 0.05$, therefore reject H_0 if $Z_p > 1.645$
Evaluation of test statistic: $p = \frac{35}{55} = 0.636$

$$Z_p = \frac{0.636 - 0.5}{\sqrt{0.5 \times 0.05 / 55}} = 6.378965$$

Decision: because Z_p is greater than the critical value of 1.645, we reject the null hypothesis and conclude that there is evidence that the data supports the hypothesis that block chain increases trust in the supply chain.

Methodology for H_2:
Multiple binary logistic regression:
Previous model: increase_trust = $\beta_0 + \beta_1$employ + $\beta_2$turnover + $\beta_3$multinational + $\beta_4$industry + $\beta_5$understand + $\beta_6$location + ε

New model: increase_trust = $\beta_0 + \beta_1$understand + ε

Model Summary			
Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	63.996[a]	.137	.188

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Figure 4.1: Model Summary for blockchain increasing trust (Created for this report)

Classification Table[a]					
	Observed		Predicted		
			increase_trust		Percentage Correct
			0	1	
Step 1	increase_trust	0	9	11	45.0
		1	6	29	82.9
	Overall Percentage				69.1

a. The cut value is .500

Figure 4.2: Classification Table for H_1(Created for this report)

As can be seen in Figure 4.3, the statistical significance of 'understand' knowledge is critical. This will be addressed in chapter 5.

Model if Term Removed[a]					
Variable		Model Log Likelihood	Change in -2 Log Likelihood	df	Sig. of the Change
Step 1	employ	-32.018	.041	1	.840
	turnover	-32.094	.192	1	.661
	multinational	-31.999	.003	1	.959
	industry	-32.787	1.578	1	.209
	understand	-35.630	7.265	1	.007
	location	-32.604	1.212	1	.271
Step 2	employ	-32.019	.039	1	.843
	turnover	-32.101	.203	1	.653
	industry	-32.787	1.576	1	.209
	understand	-35.656	7.314	1	.007
	location	-32.604	1.209	1	.272
Step 3	turnover	-32.136	.234	1	.629
	industry	-32.797	1.556	1	.212
	understand	-35.657	7.276	1	.007
	location	-32.615	1.191	1	.275
Step 4	industry	-32.819	1.367	1	.242
	understand	-35.694	7.116	1	.008
	location	-32.790	1.309	1	.253
Step 5	industry	-33.525	1.477	1	.224
	understand	-35.753	5.933	1	.015
Step 6	understand	-36.066	5.091	1	.024

a. Based on conditional parameter estimates

Figure 4.3: Statistical significance of 'understand' (Created for this report)

4.5. Findings & Discussion

4.5.1 Introduction

This section provides the results of the questionnaire. In addition, it connects any theme consistent across the 4 interviews. The ideas presented in both the survey and interviews were consistent with literature, particularly around Handfield's (2003) paradigms of how trust is earned and why trust is important in supply chain relationships.

This chapter will also provide insight into the piloting of blockchain projects currently occurring in respondent's enterprises including the inhibiters that each are challenged with and the various reasons why no project has yet moved beyond the pilot stage. When analysing the data, if a linkage to a blockchain advantage or disadvantage, the table will indicate this in a column labelled *Interview Topic*.

A *thematic content analysis* was subsequently developed from the survey and semi-structured interviews to highlight any consistent responses. These themes will be addressed in conjunction with the survey. The full thematic content analysis table is located in APPENDIX F.

The most significant factor regarding the expected increase in trust was the level of blockchain understanding. Understanding was found to have both a positive and statistically significant impact on the level of trust this technology adds to the supply chain. This will be addressed later in this chapter.

4.5.2 Findings: Company Profile

Number of employees

The first question relates to the number of employees working for the respondents company. As illustrated in Figure 4.4, almost 50% (48.3%) of respondents work for a large company (over 100 people).

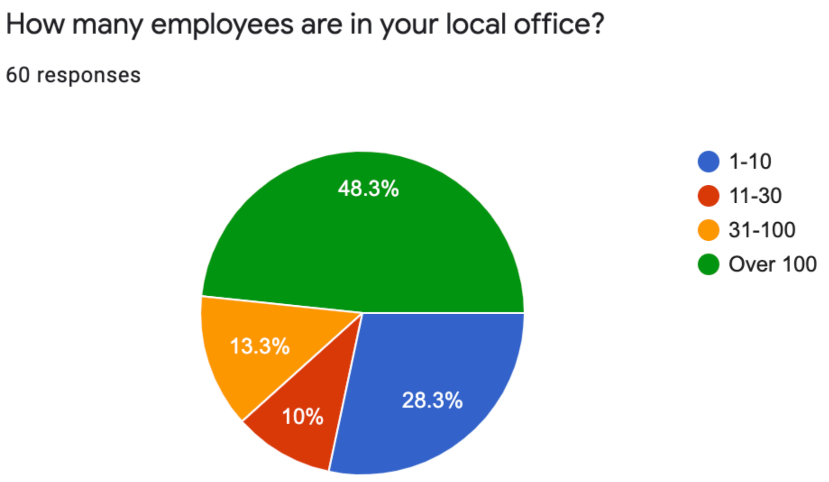

Figure 4.4: Number of employees in local office (Source: Created for this thesis)

Annual Turnover & Local vs Global

The second question relates to the annual turnover of the respondent's company. As illustrated in Figure 4.5, the spread of company turnover is wide. Figure 4.6 below highlights that the mix of local vs global companies in the results are similar.

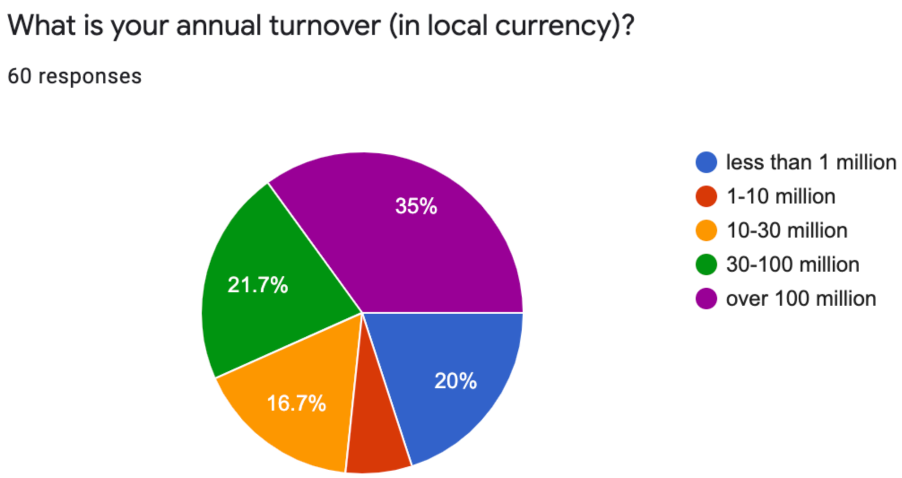

Figure 4.5: Annual turnover of company (Source: Created for this thesis)

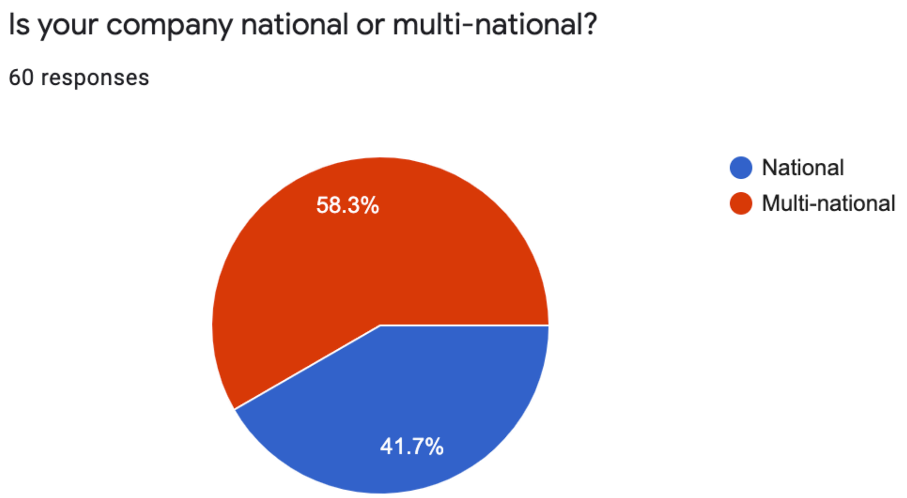

Figure 4.6: Annual turnover of company (Source: Created for this thesis)

Location

The fourth question relates to the location of the respondent's company. As illustrated in Table 4.2, the focus of respondents was in Australian and New Zealand.

Table 4.2: Location of company (Source: Created for this thesis)

Which country are you based in?	Totals
Australia/New Zealand	45
Canada	1
Fiji	1
Finland	1
Germany	1
Jamaica	1
Portugal	1
Samoa	1
Singapore	3
Turkey	1
USA	1
Vietnam	1
Grand Total	**58**

Industry Sector

The fifth question relates to the industry sector of the respondent's company. As illustrated in Table 4.3, a clear focus was FMCG and transport & warehousing.

Table 4.3: Industry Sector (Source: Created for this thesis)

What industry sector are you in?	Totals
Automotive	2
FMCG	12
Health care	3
Military	1
Not For Profit	3
Other	17
Services	7
Transport & Warehousing	15
Grand Total	**60**

Functional Area of Supply Chain

The sixth question relates to functional area of the respondents. As illustrated in Table 4.4, a core number of respondents were in distribution and the service industry.

Table 4.4: Location of company (Source: Created for this thesis)

Where in the Supply Chain is your functional area?	Totals
3PL	2
Airport Ground Handling	1
Construction	1
Distributor/Wholesaler	13
Education	1
Healthcare testing	1
Medical supply	1
Primary Manufacturer	9
Raw Material	1
Retail Apparel	1
Retail Industry	9
Service Industry	18
Social Retail	1
Supplier for Automotive OEM	1
Grand Total	**60**

4.5.3 Findings: Elements for Success and Trust in Supply Chain Relationships

Success Elements Identified by Participants

The next two questions relate to successful elements of supply chain relationships and were asked as open-ended questions to facilitate further qualitative elements and protentional discussion points for the interviews. As illustrated in Table 4.5 and Table 4.6, each respondent was requested to quantify their perception of characteristics of a successful supply chain relationship. In Handfield's (2003) conceptual paradigm of trust, he identifies *reliability* as a critical part of establishing trust. Table 4.5 also identifies both *reliability* and *trust* as important elements for successful supply chain relationships. Combined they equate to 70% of the listed elements of success.

Due to *trust* and *reliability* reporting very high in the survey, the interviewees were asked if a supplier were to use blockchain in their business, would it change their perception of the level of trust or level of reliability provided. The consensus was "possibly" but, it was important that the company was not using technology for the sake of using technology. It had to be the right fit.

Along the same theme as trust, interviewees responded that transparency for all stakeholders with "behind the scenes" processes (ie. code) was a key element that needed communicating for them to have "belief" in the system's accuracy. The interviewee elaborated that the data also needs to be visible to all relevant parties but secure from their competitor's (or hackers) reach. This aligns with the literature debate of public vs private ledgers and purists wishing to have openness and companies wanting needing privacy (Drescher, 2017).

Table 4.5: Most important success element for supply chain relationships
(Source: Created for this thesis)

What element below would you consider most important for successful supply chain relationships?	TOTALS	Interview Topic
Cost/Profit	8	
Documented Systems & Processes	6	
High priority of technology as an enabler	3	
Reliability	24	x
Trust	18	x
All of the above	1	
Grand Total	**60**	

Table 4.6: Second most important success element for supply chain relationships
(Source: Created for this thesis)

What element below would you consider SECOND most important for successful supply chain relationships?	TOTALS	Interview Topic
Cost/Profit	18	x
Documented Systems & Processes	4	
High priority of technology as an enabler	8	x
Reliability	19	x
Trust	11	x
Grand Total	**60**	

Successful Elements of Establishing Trust in Supply Chain Relationships

The next two questions relate to successful elements of establishing trust in supply chain relationships and were asked as open-ended questions to facilitate further qualitative elements and protentional discussion points for the interviews. As illustrated in Table 4.7 and Table 4.8, three key points were noticeable: 'longevity of relationship', 'partner reputation' and 'technology that mitigates/validates deviation from established agreements'. When discussing the survey question 'technology that mitigates/validates trust in established agreements', an interviewee commented that that theme perfectly coincided with blockchain's smart contracts.

Table 4.7: Most important element for establishing trust in supply chain relationships (Source: Created for this thesis)

What is the number one element that establishes trust in supply chains?	TOTALS	INTERVIEW TOPIC
Communication	1	
Consistency of performance of the business partner	1	
Cost	4	
Flexibility	1	
Gut feel' about the people in the other company	3	
How they handle problems that arise	1	
Longevity of relationship	19	x
Partner Reputation	15	x
Proven efficient processes	1	
Proven Results	1	
Rapport and open working relationships	1	
Technology that mitigates/validates deviation from established agreements	11	x
Transparent, mutually benefiting business practice	1	
Grand Total	**60**	

Table 4.8: The biggest benefit from establishing trust in supply chain relationships (Source: Created for this thesis)

What is the biggest benefit from establishing trust in supply chains?	TOTALS	INTERVIEW TOPIC
Cost reduction	6	x
Efficiency	24	x
It varies day to day	1	
Reduced Supplier Management Time	6	x
Risk Mitigation	22	x
All of the above, including the ability to plan and scale confidently	1	x
Grand Total	**60**	

Trust Issues in Supply Chain Relationships

Participants were asked if trust was a current issue in their supply chain relationships. As illustrated in Table 4.9, of the 60 respondents, 68% have trust issues with some of their current relationships. When considering blockchain and trust, two levels of trust can be considered. There is a certain level of trust that the tech brings to the implementation and the level of trust the employee has in its capability. The trust considered in this question relates to type of trust found (or diminished trust) in supplier relationships.

The overtly obvious question regarding trust issues was why, if trust is an issue, do they continue relationships? In the interview, this was addressed, and the responses were:

- Cost of changing is too great

- Global decision and loyalty is important to our head office so no opportunity to chance to change
- Other suppliers are less trustworthy

It was evident that there was a power imbalance with the particular respondent that had no choice to change suppliers based on a directive from corporate head office (due to the cultural norms surrounding loyalty and longevity).

Table 4.9: Companies that have trust issues in supply chain relationships
(Source: Created for this thesis)

Do you consider trust as an issue with your suppliers?	TOTALS	INTERVIEW TOPIC
No	19	
Yes	17	
With some	24	x
Grand Total	**60**	

4.5.4 Findings: General Discussion

Statistically, multinational firms and firms with higher annual turnover were less likely to express an increase in future trust in the supply chain if blockchain were implemented, although these observations were not statistically significant.

The number of employees, annual turnover, whether a company is multinational, the industry and the location of company do not have a significant impact on the expected level of trust in supply chains should blockchain be implemented. Therefore, in the opinion of the respondents that were aware of blockchain's use cases, regardless of the type of company (sector, turnover, etc), trust would increase with the implementation of blockchain as illustrated in figure 4.7.

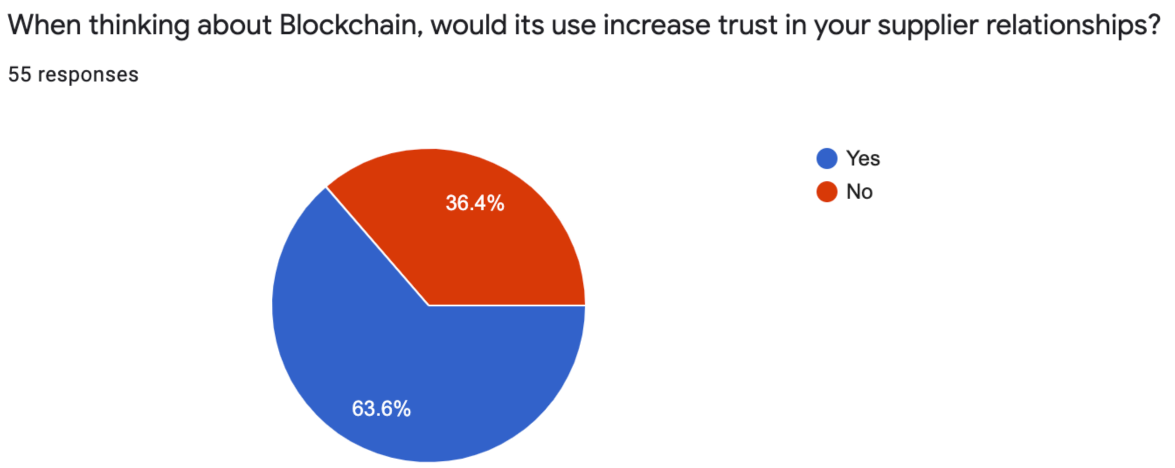

Figure 4.7: Survey: Trust increase if blockchain implemented (Source: Created for this thesis)

Figure 4.8 made it clear that the majority of respondents recognised the value of strategic alignment with their supply chain partners.

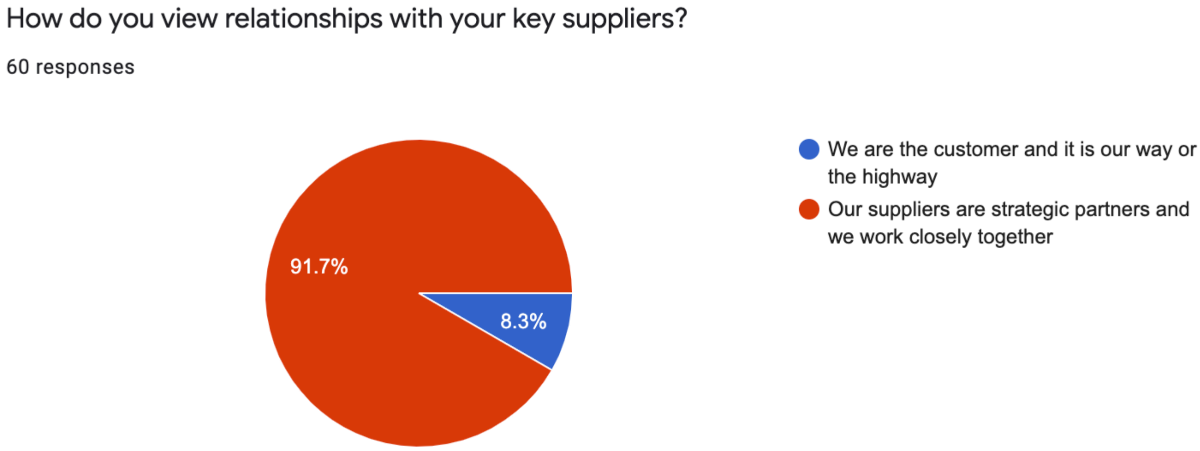

Figure 4.8: Customer and Supplier Relationships viewpoint (Source: Created for this thesis)

4.5.5 The Importance of the Variable 'Knowledge' Regarding Blockchain

The research question asks if blockchain could increase trust in supply chain relationships and it was statistically significant that *Knowledge/understanding* was a clear variable that could improve the rate of blockchain adoption in enterprise. Throughout the analysis of the survey data, it was evident that the level of understanding about blockchain was moderate to low. Table 5.9 indicates that 88% of surveyed respondents have only moderate knowledge. Emerging technologies such as blockchain can be perceived as highly technical and as the survey data shows, this was one of the identified barriers to many surveyed company's decision to not trial or, not proceed to full implementation. One thought is that the 'time to know' of blockchain is short compared with other disruptive technologies and in addition, it has not had main adoption in other companies for the benefits to become widely known. Based on conversations amongst colleagues and other professionals, it was expected that the survey results of this thesis would show that Bitcoin would have negatively influenced the status of blockchain or participants seeing blockchain and Bitcoin being one and the same but, in the opinion of the respondents through surveys and the interviews, this was not the case. Table 4.10, Table 4.11, Table 4.12, and Table 4.13 highlight the responses that support this argument.

Table 4.10: Level of understanding about blockchain (Source: Created for this thesis)

Knowledge/Understanding Level	TOTALS	PERCENTAGE
Non Existent-Low	8	13.0%
Moderate-low	18	30.0%
Moderate	27	45.0%
Moderate-High	5	8.3%
High	2	3.3%
Grand Total	**60**	**100%**

Table 4.11: Length of time known about blockchain (Source: Created for this thesis)

When did you first hear about Blockchain?	TOTALS
Don't know Blockchain	5
Less than 1 year ago	6
1-3 years	28
3-5 years	17
Over 5 years	4
Grand Total	**60**

Table 4.12: Seek information vs Introduced to blockchain (Source: Created for this thesis)

Did you actively seek out information personally on Blockchain or was the information presented to you by someone else in the company?	TOTALS
Don't know blockchain	5
I sought blockchain info out myself	40
Someone else in my company suggested it	15
Grand Total	**60**

Table 4.13: Level of understanding between blockchain and bitcoin (Source: Created for this thesis)

What answer best captures your understanding of the technology?	TOTALS
Bitcoin and Blockchain are one and the same	4
Bitcoin has no relationship to Blockchain	2
Bitcoin is only one use case for Blockchain	46
I don't understand what Bitcoin is/ Never heard of Bitcoin	8
Grand Total	**60**

4.5.6 Blockchain Projects Amongst Respondents

A quick overview is provided to the reader of the various levels of interest across the 60 respondents. It was clear that blockchain was very early in its entry to mainstream adoption. 77% of respondents either did not know blockchain at all or had a company that, to their knowledge at least hadn't considered it as highlighted in Table 4.14. This must be considered in perspective of the breakdown of the companies that are represented by respondents. Over 48% of the respondents have over 100 staff and 35% have a turnover of over $100 million. Of note however, of the 14 respondents that had run a pilot, 79% recognise they have trust concerns in their supply chain. A particularly resounding theme across all 60 respondents is that none have made it past the pilot stage as shown in Table 4.15.

Table 4.14: Blockchain Consideration in Company (Source: Created for this thesis)

Has your company considered using or currently using Blockchain?	TOTALS
Don't know blockchain/Other	5
No	41
Yes - But chosen not to deploy	5
Yes - Will potentially use in the future	9
Grand Total	**60**

Table 4.15: Blockchain Go Live Yet? (Source: Created for this thesis)

Have you gone live with any Blockchain projects yet?	TOTALS
Yes	0
No	60
Grand Total	**60**

There was no single item that stood out as to why the blockchain had been inhibited in the pilot as demonstrated in Table 4.16. Similarly, the spread of reasons was evenly spread. Unfortunately, with such a small list of respondents that have considered/are considering blockchain, it is not considered a clear representation of the populate. Based on interviews conducted by Liotine, Pagano & Varma Gadiraju (2017) with large enterprises including, it is expected that disruptive technologies will revolutionise supply chains over the coming years. Their list expands to include 3D printing, drones and autonomous vehicles and conclude that ecommerce is a driving force behind the shift.

Table 4.16: Blockchain Inhibitors in the Process (Source: Created for this thesis)

What have been the inhibitors of Blockchain adoption in your company?	TOTALS
Company's lack of technological resources	2
Cost	3
Low in project priority list	2
Managerial "buy-in"	1
Do not want to be an 'early adopter' company where technology still needs further proof	1
Maturity of Technology	2
Other	3
Grand Total	**14**

Table 4.17: Blockchain Decision to Not Go Live/Go Live Yet (Source: Created for this thesis)

What have been the 'challenges' in achieving blockchain adoption in your company?	TOTALS
Company's lack of technological resources	4
Cost	2
Low in project priority list	2
Managerial "buy-in"	1
Maturity of Technology	3
Other	2
Grand Total	**14**

Of the 9 respondents that will consider blockchain in the future, traceability and authenticity appear to be a focus area. Table 4.18 describe the various focus areas being considered by each respondent.

Table 4.18: Blockchain Areas in the Future (Source: Created for this thesis)

What areas are you considering using Blockchain for?	TOTALS
End-to-end traceability	6
Product Authenticity (anti-counterfeit)	5
Payments	4
Proof of provenance (where item originated)	4
Customer/Patient Data or Digital Identitity	2
Smart Contracts	4
Grand Total	**9**

4.5.7 Review of Findings

It was made clear through the research process that trust is recognised as a concern by many local and global companies. The overarching theme revolves around the not so simple question regarding the formation of supply chain relationships, what is there to gain or alternatively, what is there to lose. Despite the sample size being somewhat smaller than anticipated, it is not unrealistic to consider the findings are similar to a great many companies across similar industries and regions.

The findings of this report are strongly reflective of the literature presented in terms of trust and its importance in effective and efficient supply chain relationships. The level of trust varies based on a multitude of characteristics and ultimately helps or hinders efficiency and effectiveness in the supply chain relationships explored through the survey and interviews.

The results made it clear that for any emerging or exponential technology to be accepted in an enterprise, adequate exposure to the benefits that the technology would bring was critical. Understanding was the most important factor (statistically significant) for blockchain adoption.

5. Conclusion

This research aims to explain types of trust prevalent in supply chain relationships, the corresponding innovation required to successfully adopt new processes revolving around emerging technologies and the effect that blockchain may have on trust in a supply chain. Through a detailed literature review including the creation of a conceptual model and establishment of an ontological and epistemological viewpoint to the research, the author was led to a complementary research methodology. This proposed methodology connected the author to appropriate research methods and measurements for qualitative research including case study analysis through semi-structured interviews. Finally, a critical review of the research plan was undertaken to ensure reliability and validity were considered and addressed. The findings and conclusions from the research are best summarised in the later part of this chapter.

Despite a great deal of hype around blockchain, there is limited published academic research in the use of blockchain in supply chains. In consolidating the advantages and disadvantages of blockchain use in industry, practitioners and future researchers will have a useability framework to build upon.

This research thesis also has a great deal of focus on trust, in particular, trust factors in supply chain relationships. Through the documentation process of defining types of trust in strategic partnerships and defining the cooperative benefits of improved trust between supply chain partners, this research has emphasised a compilation of incentives for a collaborative development proposition of blockchain across the end to end supply chain.

The research undertaken as part of this work presents the defining factor for blockchain's mainstream adoption as knowledge and understanding of the technology and provides a focal area to build upon in future research.

Neuman (2006) considers reliability and validity as the overarching issues relating to measuring the constructs of all research. At a foundational level, Neuman defines reliability to be dependable or consistent and validity to be truthful but highlights that while social researchers recognise the underlying ideologies, generally don't use these distinct labels. For consistency in principles, the author will continue to utilise these headers.

Reliability

Contrary to the premise of research reliability being repeatable, the very nature of mixed methods research often doesn't allow for this consistency within an organisation (Neuman, 2006). Evolving and utilising unique measurement techniques, Neuman argues that quantitative rigidity could fail to recognise the diversity that is present in society. Particularly relevant to an innovative technology such as blockchain, it's evolutionary cycle is virtually never static. To aid in ensuring that unreliable data is minimised, existing supply chain concepts will be used to evaluate what is effected when blockchain is introduced. The identified classifications and key concepts will be coded to ensure consistency in the approach take to operationalise the constructs.

Validity

Validity in mixed methods research is expressed by Neuman (2006) as authentically portraying the interactions between players. Context plays an important role in data validity. The author seeks to provide validity through interviewing a range of stakeholders in the company's supply chain to ensure individual perceptions are captured. This focus on 'truthfulness' will ensure the author accurately depicts the events and is not biased to prove a particular position about blockchain.

The research was performed in the supply chain sector in a western culture. It is expected that culture, regulation, and the expectations placed on supply chain relationships in an Eastern country may differ from Western country. However, for the success of blockchain in a global supply chain, it is important that the identified qualities are transferable across various cultures, industries, and research areas. This is also expected to be the case with blockchain disadvantages. It is expected that many generalizable concepts will appear, but larger companies may see different success levels due to available resources.

Given the evolutionary nature of technology, consistent increases in the computational processing power of computers and the need to stay competitive, there will always be a need to survey the supply chain landscape regarding its use of technology. It is recommended that future research considers a longitudinal study to assess the rate of change and subsequent adoption of emerging technologies.

As argued in this research thesis, relationship trust is dynamic in nature and once earnt, can be lost again by a few small actions. Future research should consider how societal attitudes surrounding trust in supply chain relationships adapts to the influences of technology at its different levels of maturity.

Finally, through further longitudinal studies there is academic value in capturing the opinions of participants in the supply chain about their barriers to tech adoption while they work through disruption and an eventual digitalisation of its supply chain.

Trust, and distrust manifests itself in various forms and consequently aids or distracts supply chain relationships as they seek to establish collaborative partnerships. The reliance on intrinsic trust that is created through business interactions and the associated risk if it compromised can be greatly reduced by the use of an emerging technology like blockchain.

Regardless of the industry, the geographical region or the size of the company, there will always be a power imbalance in relationships. There will always be a reason for trust to exist in business relationships and ultimately contribute to their level of success (Beckett & Jones, 2012). History shows that recurring attempts to introduce counterfeit product into the market or an entity trying to take advantage of trust regardless of whether the other party is personally known to them (failure to pay for goods, sell product that is not it states it is, etc) is to be expected. This research thesis has highlighted this is a perfect use case for blockchain implementation due to its immutable qualities. But, for blockchain or similar technical solutions to gain greater adoption, suitable consideration must be given to the two types of trust at play: trust in the supply chain relationship and trust in the technology and how they can complement and strengthen each other. Enterprises that are hesitant to adopt new technologies must find ways to counteract the current impedances they face.

It is well documented in academic literature the importance of management's support for a project to succeed (Patil, 2019; Shao, Feng, & Hu, 2016). The themes, of the research highlights the importance of both management buy-in and the understanding of the technology. Therefore, focus must be to educate senior management of the benefits blockchain would bring to the organisation. It would be naïve to not consider cost as a contributing factor of adoption, particularly for small to medium companies that do not have inhouse technical or support alternatively, are resistant to outsource this type of system. In a similar process to understanding of the technological benefits, senior management must be actively exposed to the long-term gains exponential technologies can bring to the organisation allowing employees to focus on value-add activities.

2020 was a stark reminder of how many supply chains failed to consider the level of risk they could be exposed to when disruption fuelled by a disaster like Covid occurs (Flynn, Cantor, Pagell, Dooley, Azadegan, 2021). Resilience and agility differentiated competency from fragility in supply chain networks and has certainly given many organisations reason to reconsider their inadequacies related to supply chain disruption. A heightened need for greater visibility, efficiency and effectiveness is partially fulfilled through the digitalisation of an organisation's supply chain. It is recommended that organisations consider blockchain to aid in this pursuit of systemisation of processes and information flow to allow them to make informed decisions and mitigate their exposure to risk.

In the words of one of the most influential of all modern thinkers, *"I'm not upset that you lied to me, I'm upset that from now on I can't believe you."* - Friedrich Nietzsche (c. 1860-1879)

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APPENDIX A – COVER EMAIL/INTRODUCTION FOR SURVEY

Thank you for taking the time to complete this survey. It is research being undertaken as part of my Master in Supply Chain Management (research thesis) at Massey University in New Zealand. The objective is to obtain expanded understanding on the barriers to acceptance of use of technologies such as Blockchain.

For the purpose of analysis and recording, all responses will be aggregated and no individual or company identifying data will be included in the summarisation of responses. The email is requested for validation of the uniqueness of the participant. The survey is expected to take approximately 5-10 minutes of your time.

Should you have any queries about this survey or research then please do not hesitate to contact either myself on email: liam.french@me.com or mobile +61 412 175 077 or alternatively, my research supervisor Mr Alan Win email: a.g.win@massey.ac.nz or mobile +64 21 751 479.

APPENDIX B – SURVEY QUESTIONS

#	QUESTION	OPEN-ENDED
1	How many employees are in your local office?	
2	What is your annual turnover (in local currency)?	
3	Is your company national or multi-national?	
4	Which country are you based in?	
5	What industry sector are you in?	
6	Where in the Supply Chain is your functional area?	X
7	What functional area of the business best describes your role?	X
8	How do you view relationships with your key suppliers?	
9	What element below would you consider most important for successful supply chain relationships?	X
10	What element below would you consider SECOND most important for successful supply chain relationships?	X
11	What is the number one element that establishes trust in supply chains?	X
12	What is the number one benefit from establishing trust in supply chains?	X
13	Do you consider trust an issue with your suppliers?	
14	Is your company quick to adopt relevant technology?	
15	What is the biggest barrier to new technology adoption?	X
16	What is the 2nd biggest barrier to new technology adoption?	X
17	What emerging technologies are known to you/your company?	X
18	Has your company considered using or currently using any of these emerging technologies in your supply chain?	X
19	Had you heard about Blockchain before this survey?	
20	When did you first hear about Blockchain?	
21	Did you actively seek out information personally on Blockchain or was the information presented to you by someone else in the company?	
22	What level of understanding do you believe you have of Blockchain?	
23	What answer best captures your understanding of the technology?	
24	When thinking about Blockchain, would its use increase trust in your supplier relationships?	
25	Has your company considered using or currently using Blockchain?	
26	Have you gone live with any Blockchain projects yet?	
27	What have been the 'challenges' in achieving Blockchain adoption in your company?	X
28	What areas are you using/considering using Blockchain for (tick all relevant)?	X
29	What have been the inhibitors of Blockchain adoption in your company?	X
30	What were the main reasons Blockchain was not adopted in your company?	X

APPENDIX C – CORRELATION ANALYSIS OF VARIABLES

	employ	*turnover*	*multinational*	*industry*	*understand*	*location*
employ	1					
turnover	0.731136776	1				
multinational	0.193266022	0.229442076	1			
industry	-0.007849136	-0.196327253	0.006074904	1		
understand	0.017913732	0.039745861	0.120159994	0.144489553	1	
location	-0.127178167	-0.18728294	-0.095618289	-0.086404694	-0.232114681	1

APPENDIX D – CODE BOOK FOR QUANTATIVE ANALYSIS OF VARIABLES

	increase			employ			turnover
no	0		1-10	1		less than 1 million	1
yes	1		11-30	2		1-10 million	2
			31-100	3		10-30 million	3
			Over 100	4		30-100 million	4
						over 100 million	5

	multinational			industry
multinational	1		Automotive	1
national	0		FMCG	2
			Health care	3
			Military	4
			Not For Profit	5
			Other	6
			Services	7
			Transport & Warehousing	8

	understand			location
novice	1		Australia/New Zealand	1
expert	10		Other country	2

APPENDIX E – DATA FOR QUANTATATIVE ANALYSIS OF VARIABLES

increase_trust	employ	turnover	multinational	industry	understand	location
0	1	1	1	4	4	1
1	1	1	1	7	5	2
1	4	4	1	8	4	1
1	4	5	1	2	5	2
0	4	5	1	8	6	1
1	1	4	1	6	3	1
1	1	1	0	5	5	1
1	4	4	0	6	4	2
1	4	5	1	2	5	1
1	4	5	1	8	3	2
1	4	5	0	6	6	2
1	1	5	0	3	4	2
1	1	1	0	5	3	2
1	4	5	0	6	7	2
1	1	1	0	6	2	2
1	3	4	1	6	3	2
1	4	2	0	5	4	1
	4	5	1	7		1
1	4	5	1	6	5	1
0	4	4	0	6	4	1
	3	1	1	7		2
	4	2	0	3		2
1	1	3	1	2	6	2
1	3	3	0	6	2	2
0	3	4	1	2	3	2
1	3	4	1	3	6	1
1	1	1	0	7	3	2
0	1	1	0	7	4	2
1	4	4	1	2	5	2
0	2	3	0	6	5	2
0	1	1	0	6	2	1
0	4	5	0	7	3	2
1	4	5	1	8	5	2
0	4	5	1	6	1	2
	3	5	1	2		1
0	4	5	0	6	4	1
0	2	3	0	2	1	2
	2	4	1	8		1
1	4	3	1	8	4	2

1	4	5	0	2	3	2
1	4	3	1	8	5	2
1	4	5	1	2	5	1
0	1	1	1	6	5	2
1	1	1	0	6	3	2
1	3	4	1	2	3	2
1	4	5	1	2	1	2
0	2	4	1	2	2	2
0	4	5	1	1	2	2
1	2	3	0	8	5	1
0	4	5	0	6	5	2
0	4	3	1	8	2	2
0	4	4	1	8	3	2
0	1	2	0	8	2	2
1	1	3	0	1	5	2
1	1	2	1	8	5	2
0	4	5	1	8	4	1
1	2	3	1	8	5	2
0	3	4	1	8	6	1
1	4	5	0	6	5	1
1	1	1	1	7	8	2

APPENDIX F – THEMATIC CONTENT ANALYSIS

Type of Data	Class/Identifier	Summary	Interview Themes
Data on behaviour	Testing Status	Keyword identification: Future potential/Not deployed/Other	
Data on intentions	Other use cases identified in testing phase	Keyword identification: Traceability, provenance, authenticity, patient data, payments	
Data on motivations	Initial motivators to test blockchain	Keyword, phrase, sentence: partner feedback,	
Status and state of affairs	Sector	Keyword identification: Public/Private	
	Industry	Keyword identification. Eg. electronics, food, healthcare	
	Turnover	Keyword identification: Revenue	
	Demographic data	Country, level of education, cryptocurrency regulations	
	Stakeholder type (where in supply chain)	Keyword identification: Eg. Raw material sup, Manufacturer, Distributor, Transport, Other	
	Current trust issues	Keyword identification: Yes, No, With some	
Attitude and opinion	Longevity of Relationship	Keywords: Cost, Re-establish Trust, Reliability	Cost to change, hard work to establish new trust level
	Market: premium or low cost	Keywords: Lowest cost provider, premium	Price wins out most of the time due to our product profile, Cost is important but will look at long options to save cost
	Partner Reputation	Keywords: Industry leader, economies of scale	Cultural fit, supplier has better buying power than others
	Technology Implementation	Keywords: future proof, forward thinking, efficient, early adopter, non-risk averse	Dynamic company, Need to ensure tech is used appropriately rather than the "new thing", visibility & transparency. Secure data
	Perceived trust in company supply chain	High/Med/Low	
	Significant statements	Keyword, phrase, sentence:	Conceptually, trust would be increased if introduced. I don't know enough about it to make informed decisions, Small bit of reading seems positive
	Advantages and disadvantages identified	Keyword, phrase, sentence: biggest use case for blockchain in your industry?	ADVANTAGES: FMCG/Retail: Provenance. Healthcare/Medical: Proof of transaction (record keeping) Primary

			Manufacturer/Distribution/Wholesaler: Smart Contracts & Provenance DISADVANTAGES: The unknown. Don't know what you don't know.
	Risk	Keywords: Risk, Risk Mitigation, Risk Planning, Scenario Planning, What-If Analysis	
	Senior management support for project	High/Med/Low	
	Team support for the project	High/Med/Low	
	Level of innovativeness of other supply chain participants	High/Med/Low	
Awareness/ knowledge of data	Expected costs: development and cost to serve	$ value	
	Expected savings: transactional and other	$ value	