Blockchain and Distributed Ledger Technologies For Supply Chain Traceability:

Industry Considerations and Consumer Preferences

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This work is dedicated to my parents

and everything they have sacrificed to support my education.

Abstract

Several businesses and academic circles were quick to proclaim blockchain, the distributed ledger technology behind digital currencies, as the solution to a plethora of industry challenges. That was especially true for supply chain management and traceability applications for coffee products, where the technology's features were viewed as a potential solution to longstanding issues of communication inefficiencies, production monitoring, and communicating provenance information to the end consumer. However, despite the excessive amount of investment, research, and experimentation, blockchain growth and adoption have stagnated. This thesis suggests that a plausible reason for the current gridlock the technology finds itself in lies in the absence of primary research that goes beyond its technical implementations and provides clear insights on both how industry professionals understand blockchain and structure their decision-making process to adopt it, as well as on how consumers perceive coffee products that utilise the technology for traceability and provenance purposes.

In attempting to fill that knowledge gap, add to the overall understanding of consumer perception of provenance and traceability information and, ultimately, provide companies and organisations with actionable suggestions and insights, this PhD answers two critical questions. One addresses how industry decision-makers perceive fundamental characteristics of blockchain and identify the determining factors for deciding whether they need to adopt and implement the technology in their supply chains. The second examines using blockchain as a traceability certification solution in the coffee industry, how consumers will perceive products that utilise it, and how it compares with existing traceability certifications in the market.

The online survey used to explore the views of industry professionals revealed that despite the overall positive attitudes around blockchain and the importance the technology plays in their future business plans, issues around regulatory compliance, operational frameworks and concerns around the role and nature of system participation are hindering broader adoption and implementation. Inevitably, the proposed decision-making flowchart revealed that blockchain was a suitable business solution for less than half of them. At the same time, a questionnaire based on an extended version of the Theory of Planned Behaviour combined with an online experimental study on multiple coffee certifications revealed that consumers positively value the features offered by a blockchain traceability system and found it easy to comprehend the proposed phone app format of presenting provenance information. However, a possible equation effect emerged when blockchain was compared with multiple traceability certifications in a market-like environment, highlighting the importance of consumer awareness around provenance information and the importance of product differentiation. The multifaceted insights provided in this thesis can significantly contribute to helping businesses and organisations formulate their strategies for implementing blockchain in their supply chains while also adopting a user-centred approach of considering consumer preferences and attitudes around the technology.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

DLT	Distributed Ledger Technologies
NFTs	Non-Fungible Tokens
SCM	Supply Chain Management
TPB	Theory of Planned Behaviour
PoW	Proof of Work
PoS	Proof of Stake
ERP	Enterprise Resource Planning
WTP	Willingness to Pay
QR	Quick Response
MTurk	Amazon Mechanical Turk
ROI	Return on Investment
PBC	Perceived Behavioural Control
WTB	Willingness to Buy
NARA	New Attributes Relative Advantage
HIT	Human Intelligence Task

Acknowledgments

I still remember reading various blogs and comments online when embarking on this PhD, suggesting that it would inevitably be a personal and oftentimes lonely process. Yet, as much as this indication was accurate, this work would not have been possible without several people's unwavering support and encouragement.

First and foremost, I would like to thank my supervisors, Professor Thomas Chesney (Nottingham University Business School) and Professor Derek McAuley (Horizon Digital Economy Research Institute), for their continuous support since the beginning of this PhD and for giving me the space to explore different research paths and ideas while bringing me back to focus when these academic journeys led me astray.

Equally, I would like to express my unending gratitude to the entire team at the Horizon Centre for Doctoral Training for offering me a position to conduct my PhD at the University of Nottingham and for being there every step of the way, particularly during the last two years of severe disruptions caused by the COVID-19 pandemic. The management team at the Centre, Dr Andrea Haworth and Monica Cano, did everything in their power to minimise the pandemic's impact on the progress of my work, as did the entire management and administration team at the Nottingham University Business School, to which I am also thankful.

I am also highly indebted to my external partner, the Digital Catapult, for enabling this PhD. From the very beginning, Dr Robert Learney provided me with guidance, research ideas to explore, and feedback on my work, while Dr Catarina Fernandes ensured that my collaboration with the organisation was as smooth as possible. I would also like to thank them for facilitating my placement at Digital Catapult and bringing me in touch with their industry network, which was crucial for the first stage of this work.

During these years, the support and camaraderie of fellow PhD students were critical in getting through the strenuous research process and the numerous days of hard work. From a quick chat at lunch and discussions during trips to attend summer schools across the country to our online meetups and virtual retreats during the pandemic, being there for each other was essential in maintaining the headspace that allowed this work to be completed.

Last and most certainly not least, this PhD and my entire academic journey, for that matter, would be unbearable without the unconditional love and support of family and friends. I thank them not only for being there for me all these years but for understanding and tolerating my long periods of absence from their lives. I am also grateful to my partner, Violeta, for her support throughout this process and for challenging me to grow as an academic and, more importantly, as a person.

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1 General Introduction

Back in 2015, when discussing the first boom of cryptocurrencies and their supporting infrastructure (i.e., blockchain), an article from the editorial pages of The Economist titled "The Trust Machine" pointed out that "The real innovation is not the digital coins themselves, but the trust machine that mints them - and which promises much more besides" (The Economist, 2015, p. 13). The governance of emerging technologies and innovations is a challenging procedure for contemporary organisations (Stilgoe et al., 2013), especially when these innovations are highly disruptive in nature. As with the early days of the internet, there is a great amount of speculation and hype around blockchain technologies, and, in many cases, the fear of missing out or purely speculative motives have led to hastily moves from organisations without examining the specific context within which these technologies are developed and the overall problems they are trying to solve (Labazova, 2019). As Mark Russinovich, the chief technology officer of Microsoft Azure, suggested, there is firm certitude that this technology will play an important role moving forward. The real question is where and how (Popper & Lohr, 2017).

My PhD journey started in 2017, in the midst of the blockchain hype and its promise of radical business transformation, and almost half a decade later, the industry hyperbole around blockchain applications finally seems to settle down, opening the road to a more sober and eventually realistic approach of what is and is not possible. To a certain, and one might argue inevitable, extent, this PhD has also followed this hype cycle; from the initial inflated expectations about the possibilities and directions of my research to a hard-headed yet original attempt presented in this thesis to study the use of blockchain in supply chain management for product traceability through establishing industry considerations on key features of this technology and consumer preferences for products that utilise them, using coffee as a case study.

In this general introduction, I am going to provide the context within which this PhD is situated and identify the particular research gap it seeks to address (1.1). I will then provide an overview of my research approach and the studies conducted and outline the contribution of this work both on an academic as well as a practical level (1.2). Finally, this chapter concludes with the overall structure of this thesis (1.3).

1.1 Blockchain Evolution, Stagnation, and the Research Gap

The craze around blockchain has its roots in 2008. Right after the collapse of Lehman Brothers, which kickstarted the global financial crisis, an unknown author named Satoshi Nakamoto published a whitepaper titled "Bitcoin: A peer-to-peer electronic cash system", in which he laid out the blueprint for the first decentralised digital currency. What makes this new form of "money" distinct is that it operates on a peer-to-peer basis, and users can exchange it with no intermediaries since there is no central bank issuing it or vouching for its value, and it is not backed by any commodity (at least in the traditional sense). Instead, all transactions are processed and authorised by computers in a network (nodes) and maintained in a public distributed ledger known as the blockchain (Nakamoto, 2008). This decentralised ledger can store any type of digital information in cryptographically secured data pieces called blocks. Each new block also contains details and information about the previous block, thus creating a chain that is sealed using cryptographic hash functions. For a new block to be part of the chain, every participant in the network can validate the information added to it, and the entire network must reach consensus. Each node in the system stores an identical and continuously updated copy of the ledger while everyone participating can examine and verify its legitimacy. In simple terms, blockchain technologies offer what has been described as "verifiable accounting" (Wizner, 2018).

Nakamoto's solution was not the first to deal with the problem of security and fault tolerance of digital records. A forerunner of blockchain can be found in the mid-90s classified ad section of the New York Times, which Bell Laboratory cryptographers Stuart Haber and Scott Stornetta used as a timeline of their hashed data (Bharathan, 2020). Their AbsoluteProof software would cryptographically secure digital documents by creating a hash ID and a timestamp, making it impossible to alter the document without altering that ID. However, a copy of all digital "seals" created by this solution would not only stay in the internal server of the organisation but would also be published weekly in the New York Times, making sure, in that way, that there is a permanent public proof and no one, not even themselves, can tamper with these IDs (Haber & Stornetta, 1991). While the AbsoluteProof solution was not a global computing platform, its influence on Nakamoto (2008) is evident, considering that out of the eight citations in the original Bitcoin whitepaper, three reference Haber and Stornetta's work.

Although the AbsoluteProof software can be considered as one of the early commercial precursors of blockchain, it is important to highlight that Nakamoto's proposition was also influenced by a number of different movements, not least the Cypherpunks, and their advocacy towards privacy-enhancing security technologies and systems through cryptography, as laid out in their manifesto (Hughes, 1993). At the same time, earlier technical work on Merkle trees and cryptographically securing data structures (Merkle, 1979) and distributed, fault-tolerant anonymous peer-to-peer networks, like The Onion Router (Dingledine et al., 2004), as well as more financially oriented projects around decentralised digital money, such as the anonymous electronic payment system DigiCash (Chaum, 1981, 1983) and the decentralised digital currency BitGold (Szabo, 1998), also had a substantial influence on the development of the original blockchain protocol.

What was crucial in the uptake of blockchain compared to other solutions is the timing of its emergence. Although the higher the demand for a specific technology, the higher the economic incentives will be towards its development, with the markets facilitating the appropriate conditions (Kaiserfledt, 2006), blockchain somewhat diverges from this neo-classical economic approach. According to Hecht (2009), it is also the technopolitical context that is highly influential in the successful development and adoption of technologies. He argues that, in some cases, it is not economically motivated demand that drives technological growth but political and cultural conditions.

In the case of blockchain, the 2008 financial crisis and its aftermath had two fundamental outcomes that facilitated its uptake. The first one is a more than a decade long decline in citizens' trust towards businesses, institutions, governments, and media, which, although recently showed signs of a modest rise (Edelman, 2020), the COVID-19 pandemic has put once again to the test (Edelman, 2021). The second and potentially more substantial effect is the emergence of several alternative practices concerning the production, circulation and use of money and services, the introduction of new digital structures and business models, as well as a shift in authority and governance perception (Kostakis & Giotitsas, 2014). As a result, Nakamoto's promise for a decentralised, secure and transparent future in digital communications and exchange attracted attention both from crypto and cypher anarchists, that saw Bitcoin and digital currencies as a mainstream manifestation of their early work around privacy-enhancing technologies and economic freedom (Chohan, 2017) as well as start-ups, legacy businesses, global institutions and governments, primarily interested in the technology behind them, with some even characterising it as the most influential innovation of the next decade (Tapscott & Tapscott, 2017).

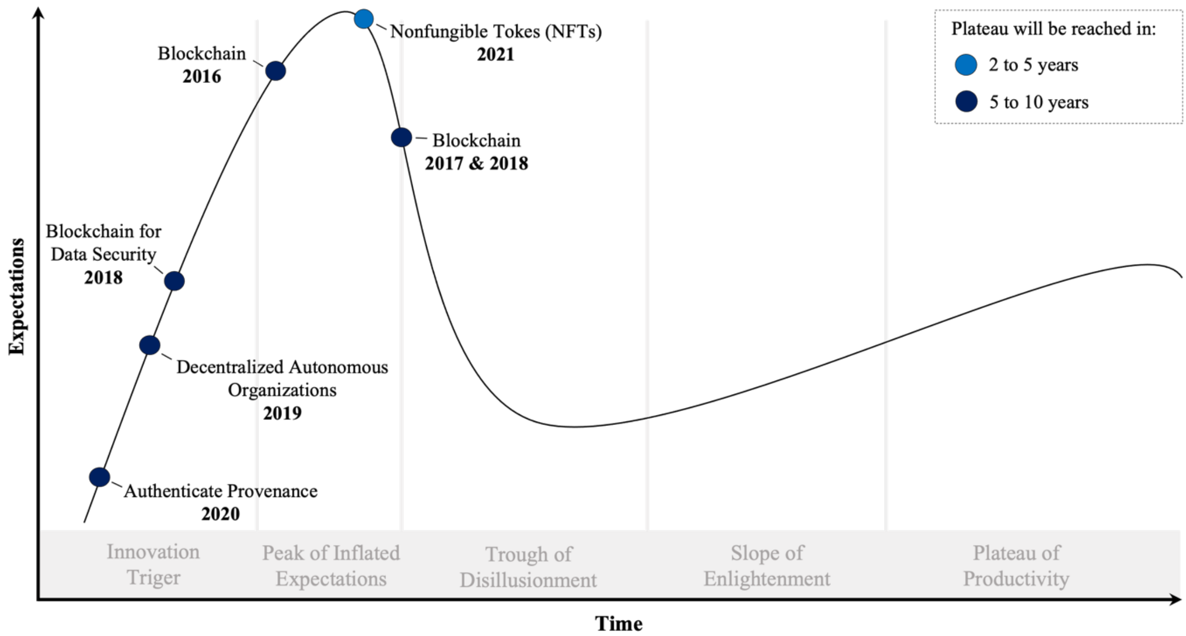
Some of the former group's socio-political advocacy, and the overall influence it exerted around the early development of blockchain, can be seen in the fact that it has been long assumed that Nakamoto (or the group of authors behind this pseudonym) was an active member and a regular contributor in the movement's renowned forum, known as the Cypherpunks mailing list (Kapilkov, 2020; Lopp, 2016). That association has been met with scepticism by some authors in the literature, with some raising concerns about the governance of these groups and the potential carryover effects it has on the development of today's blockchain systems (Champion, 2021), while others have realised a much more political connotation behind their sway, with (Golumbia, 2016) describing them as a trojan horse of far right-wing political thought and influence. Although these associations certainly contain an equitable amount of validity, they are not the main focus of this body of work which will concentrate on and examine blockchain technologies through the lens of the latter group.

Over these years, I have been following two metrics from Gartner Inc. to keep track of industry interest in blockchain and distributed ledger technologies (DLT). The first is the Strategic Technology Trends Report, which records technological advancements that the company believes will drive digital business and innovation in the upcoming years. The 2020 version of the report made an intriguing diversion, including "practical blockchain" in the year's trends and the use of the technology for transparency and traceability purposes (Panetta, 2019b), in comparison with previous years where the same trend was simply referred to as "blockchain" (Panetta, 2016b, 2017b, 2018) while in the latest versions, the trend is entirely missing (Gartner, 2021; Panetta, 2020). That latter omission reflects what several critics have discussed about blockchain and its low rate of successfully developed industry-wide platforms, despite several years of experimentation and investment (Esmaeilian et al., 2020; Labazova et al., 2019); excluding, of course, areas such as cryptocurrencies and, more recently, non-fungible tokens (NFTs). This point was amplified by Burg et al. (2018) investigation of 43 industry blockchain use-cases and start-ups, which found no or very little evidence/documentation that they have succeeded in delivering their claimed outcomes.

The second metric from Gartner Inc., which also illustrates the slowdown in blockchain excitement over the past years, is the Hype Cycle for Emerging Technologies (Figure 1). Since 2016, it has placed blockchain and DLT at the peak of inflated expectations and then through the trough of disillusionment (Panetta, 2016a, 2017a, 2019c). The former refers to early publicity and success stories of a technology where, in many cases, expectations outpace reality, while the latter stage denotes a diminishing interest due to failure of delivering expected outcomes and a slowdown in investments. The 2018 version also started including more purposeful use-cases (blockchain for data security), while from 2019 onwards, the hype cycle does not include blockchain but only specific applications of the technology, such as decentralised autonomous organisations (Panetta, 2019a), applications for the authentication of product provenance (Panetta, 2021a) and NFTs (Panetta, 2021b). This shift in the hype cycle, in addition to the strategic trends report and the research around the current state of the technology, suggests that blockchain has entered what Moore (2014) refers to as the chasm, the gap between transitioning from an early market, usually populated by a small number of enthusiast early adopters, to the more mainstream market which the large block of the pragmatist early majority occupies, and which constitutes a make-or-break point in an emerging technology's adoption cycle.

Figure 1.

Blockchain in the Gartner Hype Cycle for Emerging Technologies (2016 – 2021)



Note. Adopted from Panetta (2016a, 2017a, 2019a, 2019c, 2021a, 2021b).

Of course, that is not to say that there is no industry effort and experimentation with applicable use cases for this technology. During a summer internship I undertook in 2019 at the Digital Catapult (an Innovate UK technology hub and my external PhD partner), I had a first-hand opportunity to get involved in a couple of projects exploring blockchain applications in supply chain management (SCM) and manufacturing. One of the most engaging of those projects was The Internet of Food Things Network, a multidisciplinary project of academics and industry partners aiming to enhance the digitisation of the UK's food manufacturing digital economy and supply chain, with one of the paths explored by this project being the idea of data collaboration within the food industry via data trusts built on the blockchain. More interestingly, during my involvement in an existing project mapping all the companies and organisations utilising blockchain in the UK and the industry within which they operate, the use of the technology for SCM and product traceability was only behind the financial sector.

This observed uptake and experimentation with blockchain technologies in SCM, and specifically in reliably tracking down a product's journey, was not simply a stroke of serendipity. It coincides with a more general digital and regulatory transition global supply chains are undergoing. In a recent survey conducted by the French consultancy Capgemini (Pai et al., 2018) among 447 organisations that are investigating blockchain implementations in the supply chain domain, they reported that the main issues in procurement and supply chain management (and consequently the main drivers behind their blockchain experimentation) are the lack of traceability and transparency, the dependency on manual processes, as well as regulatory compliance in a globalised market. If we also consider consumer demands for ethical consumption (Newholm & Shaw, 2007), improved business practices, and corporate responsibility (Castaldo et al., 2009), the importance of tackling the abovementioned challenges becomes critical for a smooth and successful industry transition to the digital age while also aligning with current market and consumer trends.

For many, blockchain is a well-suited solution to address these issues since it can enhance transparency by documenting a product's journey through the supply chain, it can provide better scalability as any number of people can access it from any touchpoint, and it can provide better security through its decentralised and tamper-evident nature (Kshetri, 2018; Wang et al., 2019). That is why over the past few years, companies have transitioned from research and proof of concept stages and have released blockchain solutions to the mainstream market. For example, Project Provenance (2015) designed a decentralised system where modular programs deployed on a blockchain will track the supply chain in its entirety, covering products such as wine, fresh produce, and cosmetics. iFinca (2020) has adopted a similar solution for connecting coffee farmers and producers with the end consumer, in a bid to enhance transparency in the coffee value chain.

A significant set of questions rises at this point. Why, despite all these positive and promising aspects of utilising blockchain in SCM and product traceability, there seems to be an inability to overcome the stagnation the technology faces, and what are the critical factors behind successfully crossing Moore's chasm towards a wider scale adoption? These logical questions align with findings reported in a previous Deloitte Global Blockchain Survey (Pawczuk et al., 2019), which noted that although there is increased interest and willingness to invest in the technology, decision-makers have begun querying the benefits of blockchain in a much more substantial manner. Even the most recent survey version still portrays a tension between motives and actions (Pawczuk et al., 2021). A plausible reason behind this prolonged inertia lies in an overall focus on the technicalities of blockchain and the absence of other quality research on the topic. There is a plethora of academic and industry literature on various blockchain implementations and the technical infrastructure that supports them. At the same time, however, there is a striking absence of research on which of the features these systems offer are most important to the industry, while even less work has been conducted on whether these proposed applications pose any interest to the end consumer and if they do, which factors will influence their intention to prefer products that bear them.

As with other disruptive technologies in the past (e.g., internet protocol suite), academic research will be essential not only for the technical development of blockchain but for its design and broader adaption (Iansiti & Lakhani, 2017). As a psychologist with a background in economic/consumer psychology and behavioural design of digital services, I am particularly interested in the interactions between the economy, society, and the individual and the mechanisms underlining our choices in the digital world. In an era where new technologies emerge exponentially, so does the need to understand what guides judgment and decision making in these settings and incorporate these insights into their design. To a certain extent, blockchain applications in SCM and product traceability are standing at the intersection of these interests and being a terra incognita academic field, are surrounded with opportunities for original and coherent research as well as challenges in cutting through the noise around them.

It is this research gap that my PhD thesis will try to fulfil in two stages. Stage one addresses industry perspectives and evaluations, and it specifically attempts to answer the question of which features of blockchain applications in SCM are most relevant to industry decision-makers. Stage two explores consumer intentions and preferences around blockchain applications for product traceability in an effort to resolve the question of what are the influential factors that determine their intentions to purchase them compared to other choices in the market.

1.2 Research Overview and Contributions

In the 1st stage of my research, I explored blockchain & distributed ledger technologies implementations in supply chain management and their implications regarding trust, industry collaboration, information sharing, governance, and regulation. An online survey was utilised, targeted at industry professionals working or experimenting with supply chain blockchain applications. The survey was completed by participants from the health, pharmaceutical, energy, food, and fast-moving consumer goods industries. The findings indicate overall positive attitudes regarding blockchain implementations in SCM, especially in addressing product traceability and communication inefficiencies. At the same time, participants expressed their concerns on issues of privacy and regulatory frameworks. The lack of trust among users and safeguards around network participation were the most significant barriers to broader market adoption. One particularly intriguing finding emerged from the decision-making flowchart participants had to complete at the end of the survey, which accessed, through a series of questions, whether they actually need to use a blockchain system for a particular application they are working on, and which revealed that for less than half of participant blockchain would be an appropriate solution. This final point is of great interest and one of the primary purposes of this qualitative survey, which aimed to go beyond the conventional practice of asking general questions about investment intentions and interest regarding an emerging technology and obtain a more realistic picture of the industry's current state when it comes to blockchain.

The second stage of my research involves examining how consumers perceive blockchain applications in supply chain management and how they compare with existing traceability systems/certifications. I focused on the product traceability aspect of blockchain applications both because it emerged on the top of the list in supply chain management implementations of blockchain in my industry survey and because several companies have released products and solutions in the market that are utilising the technology in order to enhance transparency, traceability, and provenance and increase consumer confidence, including legacy business such as IBM and Microsoft as well as promising start-ups such of Project Provenance and Everledger. I also chose organic coffee as the product of interest because apart from being one of the most traded commodities in the world (International Coffee Organization, 2019), it has an increased market share in sustainable marketed products (Kronthal-Sacco & Whelan, 2020) and occupies an important place in consumers' ethical concerns on environmental production practices (K. H. Lee et al., 2015). The availability of real-world market applications for blockchain traceable coffee also played a role in this decision.

In the first study of this stage, I investigated consumers' purchasing intentions for blockchain traceable coffee and their psychosocial antecedents, utilising an extended model of the theory of planned behaviour (TPB) (Ajzen, 1991). An online questionnaire study was deployed, using two traceability systems (one based on blockchain and one on a more established traceability certification) for organic coffee. The results suggested that environmental protections, perceived behavioural control, and attitudes were the main predictors of consumer intentions to purchase blockchain traceable coffee. Another interesting detail from this study is the participants' willingness to pay a price premium for blockchain traceable coffee. Roughly 75% of participants indicated that they are willing to pay at least 5% more for the blockchain traceable coffee, with the majority price premium ranging from 5% to 30%. A research paper based on this study is now published in the British Food Journal (Dionysis et al., 2022) (see Appendix 4).

The second study of this stage expanded on the previous work. I conducted an online experiment among 516 participants using different versions of a traceable organic coffee product (traceability based on a company initiative, third-party traceability, a blockchain platform and a combination of the two latter settings), in which I recorded and compared their willingness to buy, along with a series of other measures such as their level of trust and how they evaluate each traceability feature. The results suggest that although participants recorded higher scores in trust and in their evaluation of the traceability features for the blockchain supported products, their willingness to buy was relatively the same. Furthermore, the same pattern emerged when comparing participants with low and high environmental awareness.

However, participants in the high environmental awareness group recorded higher scores in all measures than those in the low environmental awareness group. A research paper based on this study is, at the time of writing, being submitted for review to the International Journal of Consumer Studies (see Appendix 4).

On an academic level, this PhD attempts to close the abovementioned research gap by providing information on how the industry perceives the features blockchain technologies offer for supply chain management and whether they believe that these systems can provide solutions to the challenges modern supply chains face. It also aims to reveal what these new blockchain-based traceability systems imply for the consumer and the influential factors behind their intentions to purchase products that utilise them for traceability and provenance purposes. Furthermore, my research contributes to the expansion of established frameworks (i.e., Theory of Planned Behaviour) in terms of extending the product range that these frameworks can be used to explain purchasing intentions and introduce variables that can expand their predictive power. It is also worth mentioning that at the time of writing, and to the best of my knowledge, both studies in the second stage of my research are the first ones to explore consumer preferences, valuations of the features and purchasing intentions for blockchain traceable coffee.

On a practical level, the insights this research provides can be incorporated into the design of commercial blockchain platforms by unveiling which aspects of this technology matter most to both businesses and end consumers and, consequently, help overcome unlocking the growth gridlock blockchain applications in SCM find themselves in. For example, the format in which the blockchain application was presented in the coffee traceability studies positively impacted consumers. According to the findings, adding features that underline the environmental protections this system can offer could positively affect purchasing intentions. The outcomes of this research also provide a window on consumer awareness and level of knowledge around product traceability, its importance in blockchain adoption in SCM, and a possible way to enhance it, as I will discuss in the later chapters of this thesis.

1.3 Thesis Structure

The next chapter provides a thorough review of the literature and lays the groundwork upon which my research is based. It starts with an overview of the fundamentals of blockchain technology and moves toward its main characteristics and industry/business applications. I then focus on the specificities of blockchain supply chain implementations, particularly on aspects of transparency and traceability, where I identify the first research gap in the literature and formulate the first research question. The attention is then turned towards the coffee value chain, the current practices it utilises regarding traceability assurances and how blockchain aims to improve them. Finally, this chapter discusses what traceability means for the consumer and pinpoints the second research gap in the literature, followed by the second research question.

In the third chapter, I provide an overview of the research design and methodological choices made in my research. The chapter starts with the reasoning behind this thesis's two main questions. It then structures the reasoning for the industry survey conducted in stage one of my research, continues with explaining the thought process behind the first study of the second stage, and the choice of the TPB as the preferred model, and concludes with setting up the experimental study. Throughout this chapter, I also discuss the impact of the COVID-19 pandemic on my research since the initial lockdown happened in the middle of my work and severely impacted data collection. Hence, since the entire research approach had to be adjusted, this chapter offers the opportunity to briefly talk about the steps I took during each stage to mitigate the effects of the lockdowns while striving to maintain a high level of academic rigour and research integrity and not significantly deviate from the original PhD goals.

Each of the following three chapters presents the main studies of this PhD. Chapter 4 presents the findings from the survey with industry professionals on blockchain applications in supply chains management, followed by the study of consumer intentions for blockchain traceable coffee (Chapter 5) and the online experiment examining consumer preferences amongst a variety of traceable coffee products (Chapter 6). The penultimate chapter of this thesis (Chapter 7) is dedicated to a comprehensive discussion of the findings of this work. It takes a step back and critically examines the output of the three studies, how it manages to fulfil the identified research gaps and ways in which it furthers blockchain adoption in SCM. In this chapter, I also discuss the limitations of my work. Finally, the thesis concludes by providing an overview of its main contributions as well as recommendation for future research (Chapter 8).

All research materials used in the three studies, as well as relevant ethics approval forms from the Nottingham University Business School, can be found in the appendices of this thesis. This section also contains a PhD portfolio which includes publications, course work, internship details, research training, teaching, and various other related activities I undertook throughout this degree.

2 Literature Review

When discussing technological innovation and ways of managing its potential market and organisational impact, Tidd & Bessant (2021) denoted three phases for bringing a potential idea to a wider and more effective use. It all begins with the invention, which denotes the process of generating new designs and solutions. It then moves to the innovation phase, where the initial idea will be developed from a concept to a more actionable business use case. Finally, in the implementation stage, this innovation will be released in the market and further developed and refined to meet certain market conditions. One can assume that blockchain technologies are currently in the latter stage, where a plethora of applications and use cases have been proposed, developed, and released on the broader market. However, the data examined earlier suggest a stagnation in delivering at scale use-cases. Even in the financial services sector, where the technology has seen its most significant investment, applications that, in theory, should be reaching the growth stage appear to lose momentum (Higginson et al., 2019).

It is only fair to also point out that, to some degree, this lack of progress is to be expected. As Hajer (2003) points out, emerging technologies are susceptible to the "institutional void", which refers to the lack of specific frameworks and generally accepted rules upon which they can be developed. That void can, of course, include both governments and policymakers as well as wider market conditions and internal processes (Department of Trade and Industry, 2003). Since the implementation phase that Tidd & Bessant (2021) discussed is not a single event but an arduous, continuous process of re-evaluation and readjustment, it is potentially time for companies and organisations using blockchain to take a step back, rethink their overall propositions and realise in which sectors the technology truly makes sense, which practical problems it solves and how it aligns with market requirements and trends. The rest of the chapter will undertake this endeavour by examining both the academic and industry literature.

Being a new technology with a considerable amount of interest and hype, as well as a broad range of application areas, there were two important areas of consideration when approaching this literature review. The first was deliberating the relatively limited academic literature around blockchain industry use cases, in general, and applications in SCM and product traceability, as well as consumer perception, in particular. Although the amount of technical and operational literature on the topic is undoubtedly growing, research on the variables that affect industry decision-making and consumer awareness and preferences still has to catch up. Therefore, from the limited existing literature, priority was given to any primary and original research, while literature reviews, case studies and editorial or opinion pieces were also included. Although all attempts were made to include field leaders and well-cited authors, due to the limited amount of research, a broader scope of academic work was included, always ensuring both the robustness of the research as well as the quality of the journal/publication were to an appropriate scientific and academic standard. In general, literature that focused on cryptocurrencies and non-industrial applications of blockchain was not included in this work, apart from the sections where the origins of the technology are discussed. Moreover, as mentioned in the introduction, literature on the politics and governance of blockchain and DLT projects was also limited since it was not the main focus of this work.

The second area involved navigating through numerous documents of grey literature and identifying not only the materials that were relevant for structuring and supporting this thesis's arguments but also determining the reliability, reputation, and overall quality of these documents. Authoritative sources were prioritised, particularly ones from governments departments and regulatory bodies (e.g., Department for Business, Energy & Industrial Strategy, Food Standards Agency), established industry service and technology providers (e.g., Deloitte, Capgemini), and business and industry consortia (e.g., Hyperledger, Retail Blockchain Consortium). At the same time, particular importance was given towards documentation (e.g., whitepapers, reports) from well-known and reputable blockchain start-ups (e.g., Project Provenance, TE-FOOD) and larger established companies experimenting with the technology (IBM, Microsoft). Special attention was paid to minimising the use of grey literature from the myriad of smaller, and often shadier, projects, initiatives, and start-ups, as well as the plethora of opinion pieces and blog posts, which, although provided helpful information and views, often completely lacked any references and verifiable data.

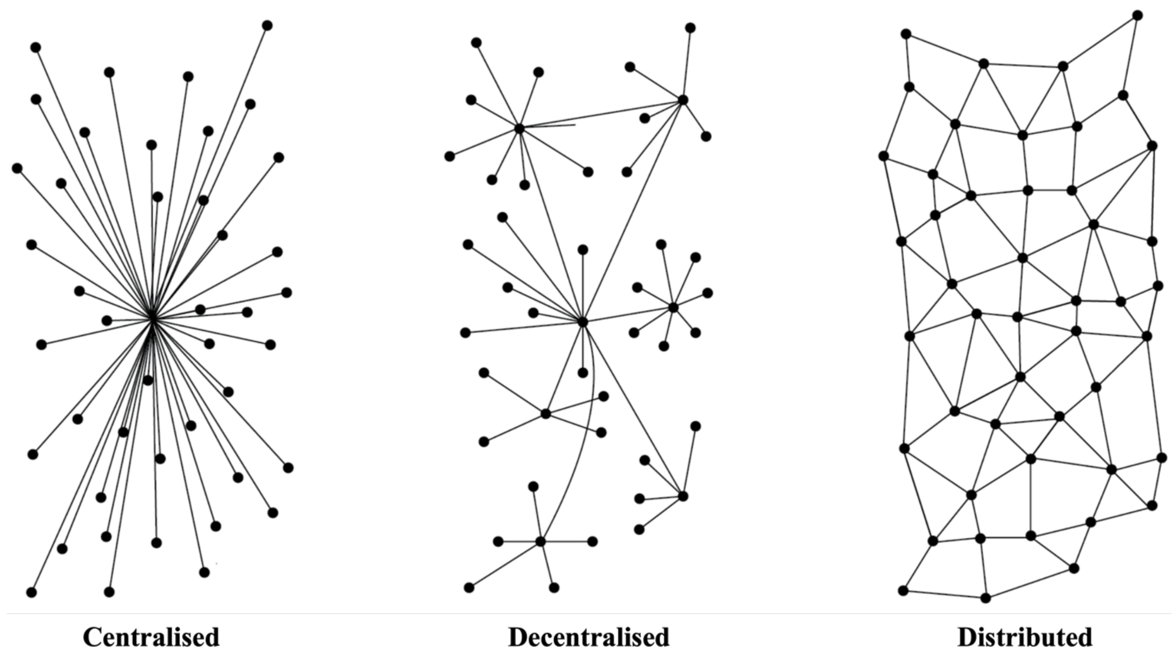
In the rest of this chapter, I will first present the inner workings of blockchain and the different types of this technology (2.1). I will then discuss its most relevant characteristics and different propositions and uses-cases (2.2). This will lead me into one of the most realistic and promising applications of blockchain, that is, SCM and product traceability, where the first research question lies (2.3). The analysis will then zoom into the coffee industry, a fruitful area for such applications that has also attracted considerable consumer interest (2.4). It will explore the potential of blockchain applications for coffee traceability and the importance of consumer attitudes, which forms the basis of the second research question. The chapter concludes with a brief overview of the rationale behind the two research questions and what they seek to address (2.5).

2.1 What is Blockchain and How it Works

In order to understand what is blockchain, one must first clarify a key term surrounding this innovation, that is, distributed ledger technologies (DLT). DLT refers to a database(s) (ledger) that can be spread across multiple computers regardless of geographical or institutional boundaries and allows participants in this network to create, disseminate and store information without the need for any known or trusted central administrator (Figure 2). Information is kept in a timely order in the ledger and is fully available for every participant to audit and verify, while unauthorised changes are very difficult, if not impossible, to make, creating, in this way, a system that is transparent and trustworthy by design (Hong Kong Applied Science and Technology Research Institute (ASTRI), 2016).

Figure 2.

Centralised, Decentralised, and Distributed Networks

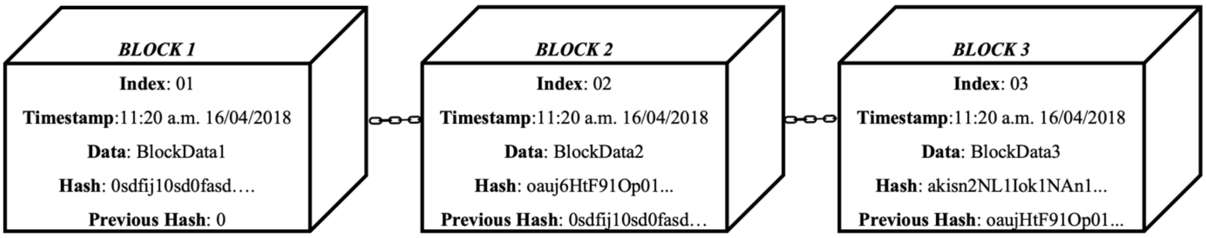


Note. Adopted from Baran (1962).

In structural terms, blockchain serves as such a distributed ledger, where any kind of information can be stored in interconnected (or chained) blocks of data (Figure 3). Each data block (starting from the first, also known as the genesis block) is timestamped and cryptographically secured using hash functions, creating a sealed and linear "chain of events" that is impossible to tamper with (Voshmgir & Kalinov, 2017). Since an identical copy of this ledger is stored and updated across all participating computers in this peer-to-peer network, instead of a single party having the authority to validate the information added to the ledger, everyone needs to authorise each new block added, and the network must reach consensus for it be part of the chain (Pilkington, 2016). Like with any other database, writers (or validators in the case of blockchain) will collect and verify transactions within a block and append it to the chain, while readers will participate by either creating transactions or by analysing and auditing the blockchain.

Figure 3.

Simplified Visual Representation of Information Stored on a Blockchain



As discussed in the introduction of this thesis, blockchain was initially developed as the backbone of Bitcoin. Therefore, Nakamoto's (2008) proposition suggested an entirely public blockchain, where everyone could participate, and placed specific governance and consensus rules, given that the system's purpose was to support a decentralised digital currency. Today, however, various approaches regarding validation and consensus have been developed, aiming for a different balance between availability, consistency, and trustworthiness (Tschorsch & Scheuermann, 2016), such as the proposition of "smart contracts", first implemented by Ethereum (Buterin, 2014). To begin with, the term "smart contract" is somehow misleading. Smart contracts are not necessarily smart, nor are legal binding documents with real-life consequences if they are not honoured. To their essence, they are lines of code that set specific instructions that will auto-execute if specific conditions (that are also initially set) are met. A real-life analogy, and the one used by Nick Szabo (1996), who first proposed the term, is the classic vending machine. What these simple forms of automata do is a type of agreement where one will input £1, press the button, and receive back a product. This simple function is already prewritten in the machine, and it accurately executes itself every time someone uses it. In a blockchain, smart contracts can be programmed to include agreement terms and specific actions between parties that will self-fulfil accordingly, allowing, therefore, transactions and agreements to take place without the need of any trusted authority, legal system or third party enforcing them (Staples et al., 2017).

2.1.1 Types of Blockchain

Being a relatively new technology, there are still no clear standards to categorise different blockchains. A practical way to differentiate between them is by using two criteria; first, whether they are public or private, referring to the level of anonymity in validators and whether they are permissioned or permissionless, referring to the level of trust in validators (Kravchenko, 2016). Figure 4 maps different blockchains systems currently developed based on those two criteria.

Figure 4.

Perceptual Mapping of Various Blockchain and DLT Systems

Note. Adopted from Kravchenko (2016); LTO Network (2019).

The upper left corner illustrates permissionless and public blockchains. Anyone can participate in the consensus process without being previously vetted, and trust in the validators is particularly low, if not absent, making the system anonymous and decentralised. The right upper corner refers to public and permissioned systems where partaking is also unrestricted, but participants need first to acquire a substantial stake in the system which will be used as a validation mechanism, and, hence, the level of trust is higher. The lower left corner refers to private and permissionless systems, which, at first, might sound odd since how can the system be accessible to everyone, but only specific people can have validation access? In this case, permissionless means that for someone to qualify, specific criteria must be met and hence such systems might be used by central governments for nationwide purposes or a company's external network (LTO Network, 2019). To this day, private permissionless blockchains remain an edge use case (Saifi, 2021). Finally, permissioned and private blockchains refer to closed systems mainly used for internal infrastructures. Legacy organisations and companies usually favour such systems since they control both access to the system and validation status, creating high levels of trust.

2.1.2 Consensus Mechanisms

The consensus mechanisms will also differ depending on the type of blockchain. The two most used mechanisms in public blockchains are Proof of Work (PoW) and Proof of Stake (PoS). In the PoW consensus mechanism (used by Bitcoin), computers in the network (nodes) compete in order to provide the solution to a complicated mathematical "puzzle" (hash function) and the first one that finds the answer (proving that they have done the necessary work) is allowed to add a new block to the chain and is rewarded with newly created cryptocurrency for its effort (Nakamoto, 2008). In the PoS consensus mechanism (used by Ethereum), nodes that will validate a transaction on the blockchain are randomly selected based on the wealth/currency they possess in the platform (stake), eliminating the need for excessive amounts of computing power since participating nodes can only validate a percentage of transactions that is reflective of their ownership stake (Buterin, 2014). However, in permissioned and private systems, the consensus mechanism differs since participants in the network are predefined. Proof of Elapsed Time (used by Hyperledger Sawtooth), for example, is a consensus mechanism in which participants in the network are given a random timer, and the first one to expire will allow the node to become a block leader and produce a new block of transactions (Olson et al., 2018).

Blockchain systems that are public (permissionless or permissioned) typically include reward mechanisms based on cryptocurrencies or internal tokens in order to incentivise the verification process (and penalise fraudulent behaviour), something that is somewhat redundant in private systems since participation is already predefined (Christie, 2018). They promote transparency, decentralisation, and reliable structures where everyone can transact without the need to trust the other side. This comes, of course, at the cost of slower transactions and potential deanonymisation (Hong Kong Applied Science and Technology Research Institute (ASTRI), 2016). On the other hand, private blockchains drop most of those characteristics since they are more centralised and controlled by trusted parties. They are, however, faster, and more suitable for optimising business and communication processes (Walport, 2016). At this stage, it is becoming clear that there is no golden rule when it comes to blockchain technologies, and each implementation provides solutions to different problems.

Vitalik Buterin (2015), the creator of Ethereum, also highlights this point in one of his articles. Altering the consensus mechanisms and the monetary rewards provided by crypto economics (e.g., PoW) can create systems with tighter control and access permissions where reading and writing are only permitted to a handful of people while maintaining key aspects of blockchain, such as decentralisation and authenticity. He proposes three categories of blockchain-like database applications. Public blockchains correspond to the upper left corner of Figure 4. Consortium blockchains correspond to the lower left and upper right parts, in the sense that a predefined number of nodes control the consensus process (with varying reading and writing permissions) and fully private blockchains, referring to the lower right corner of Figure 4, where writing and reading permissions are centralised under one or a set of organisations. The difference between the consortium and private blockchains, according to Buterin, is that the former proposes a hybrid solution between low trust (public blockchain) and a single highly trusted entity (private blockchain), while the latter resembles traditional centralised systems with a degree of cryptographic auditability attached. He concludes, nevertheless, that:

> The solution that is optimal for a particular industry depends very heavily on what your exact industry is. In some cases, public is clearly better; in others, some degree of private control is simply necessary. As is often the case in the real world, it depends. (Buterin, 2015, para. 7)

The academic literature has also followed a similar path in trying to classify blockchain. For example, Wüst and Gervais (2018) discuss permissioned and permissionless blockchains, with the differentiating factor in their analysis being who has permission to read and write on the ledger. In a permissionless blockchain, everyone has such an ability, while in permissioned systems, it is a predefined set of readers and writers. According to the authors, permissioned blockchain has two subcategories, one in which anyone is allowed to read the state of the ledger (public permissioned blockchain), and one where even reading access is restricted to a set number (private permissioned blockchain).

Finally, it is worth mentioning the existence of other initiatives in the DLT space that have moved away from the concept of blockchain and tried to implement different protocols in order to achieve the same results, such as IOTA and its tangle system (based on a mathematical concept known as directed acyclic graphs) (Popov, 2018) and Hashgraph which uses a gossip protocol for reaching consensus (Baird et al., 2020). Both systems do not need validators for any of the transactions taking place and are guided toward speed and efficiency.

Despite similarities in definitions and classifications around blockchain there is still no unanimity in industry or academia around which label fits which specific implementation of the technology. Therefore, whenever I use the word blockchain I refer to the overall technology and when referring to a specific implementation I will use the corresponding type (e.g., private permissioned blockchain).

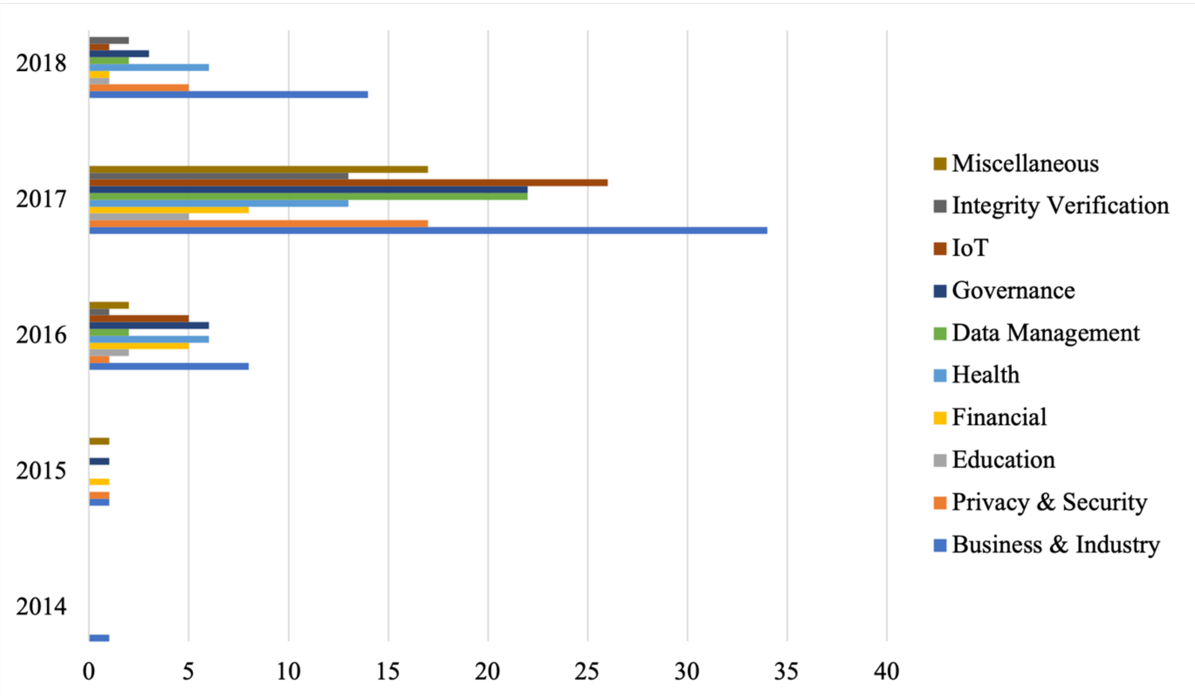
2.2 Blockchain Characteristics and Applications

The notion of a shared ledger with layered permissions as the supporting, storing and sharing data infrastructure between vetted participants is a concept that has existed for some time (Natarajan et al., 2017). The idea, however, of a decentralised distributed system that is transparent, fault tolerant and can eliminate friction in the exchange of value over the internet was actualised with the commencement of Bitcoin and cryptocurrencies. Since 2009, a variety of potential applications have been proposed that utilise different forms of blockchain and DLT, either in terms of rearranging existing infrastructures or in terms of creating new economic value. According to Zhao et al. (2016), there are three generations of blockchain. Blockchain 1.0 refers to applications created to support digital cryptocurrencies and subsequent transactions. Blockchain 2.0 includes the introduction of smart contracts and the ability to deploy applications extending beyond cryptocurrencies, and Blockchain 3.0 includes using the technology for industrial purposes in sectors such as health, energy, and agri-food. Despite the plethora of industry reports and whitepapers detailing the benefits of using blockchain for various business problems and applications, academics only recently started examining and systematically documenting these implementations.

Casino et al. (2019) conducted a structured literature review in order to identify key areas of interest for blockchain-enabled applications. Specifically, they investigated both academic and grey literature and identified the main disruptive characteristics of the technology, as well as the sectors that have attracted the most interest from the scientific community over a five-year period. The authors suggested that the four main attributes of blockchain are trust (referring to the lack of trusted third parties, and aspects like accountability and peer-to-peer transactions), context (referring to traceability and verifiability of transactions, security, and privacy), performance (referring to latency and transaction speed, maintenance costs and scalability), as well as consensus (referring to the rules of engagement and the need for verifiers). Figure 5 depicts the distribution of research articles identified over a five-year period (2014 - 2018), with industry applications of blockchain (i.e., SCM) consistently representing most of the use cases examined.

Figure 5.

Volume of Academic Articles for Domain Specific Blockchain Applications (2014 – 2018)



Note. Adopted from Casino et al. (2019).

One can observe that since blockchain was synonymous with Bitcoin during the first years of its existence, it took researchers some time to investigate the technology for other purposes outside of cryptocurrencies. What is also worth mentioning (and that is something the authors also point out) is that despite the significant investment and use-cases from the financial sector, the academic world has not shown the same amount of interest in related research output.

At the same time other researchers turned their attention towards the suitability of blockchain applications and the development of evaluation frameworks to support business decision making. Lo et al. (2017), for example, identified seven aspects of the technology that will determine its appropriateness for specific use cases. These aspects are the involvement of multiple parties, the requirement of a trusted authority, whether the operation of the application is centralised, the conflict between data transparency and confidentiality, data integrity, data immutability, and system performance (Table 1).

Multiple parties refer to operations and transactions that require several different partakers or intermediaries in order to be facilitated. Supply chains are such an example where complex and dynamic arrangements with logistical and regulatory constraints spanning across different jurisdictional boundaries have to be made. Trusted authority addresses settings where an entity is responsible for arranging and executing specific operations or altering policy procedures (such as a bank or a government). Settings where there is room for this authority to be decentralised are fitting for blockchain systems, where "centralised trust" becomes "distributed trust" and shifts from intermediaries and centralised governing bodies to the blockchain network. Centralised authority refers to whether the operations and management of an application are concentrated at a central point within an organisation. A blockchain system based on smart contracts is one where no single party handles operations, but every participant is in control of their own assets. Data transparency and confidentiality refers to the tension of whether there is a need for all participants in the network to see the published data or a higher degree of confidentiality is required. Blockchains provide a neutral platform where all participants can see published data and despite encryption techniques, information will still be shared between the network, something that might not be ideal for specific applications. Data integrity refers to the need for an application to access historical transactions, a key aspect for creating provenance and transparency and can be used for tracking assets through ownership changes. Data immutably, on the other hand, refers to blockchain's ability to provide a history of transactions that is not prone to changes and is continually replicated across the entire network. Finally, performance refers to the speed with which the blockchain network operates. This is an inherent limitation of this technology, because of the massive redundancy from a large number of processing nodes holding a full copy of the distributed ledger.

The authors go a step further and, by utilising these seven facets in their framework, evaluate the suitability of blockchain applications in different industries, namely, supply chains, electronic health records, identity management, and the stock market. Table 1 illustrates the results of their examination, which concludes with whether an industry should adopt a blockchain solution or a more conventional database. We can observe that supply chains and identity management are both suitable for implementing blockchain-based applications, mainly because both industries require transparency when it comes to information exchange, while for managing health records and the stock market, a traditional database will be more appropriate.

Table 1.

Suitability Evaluation of Blockchain Characteristics for Various Use Cases

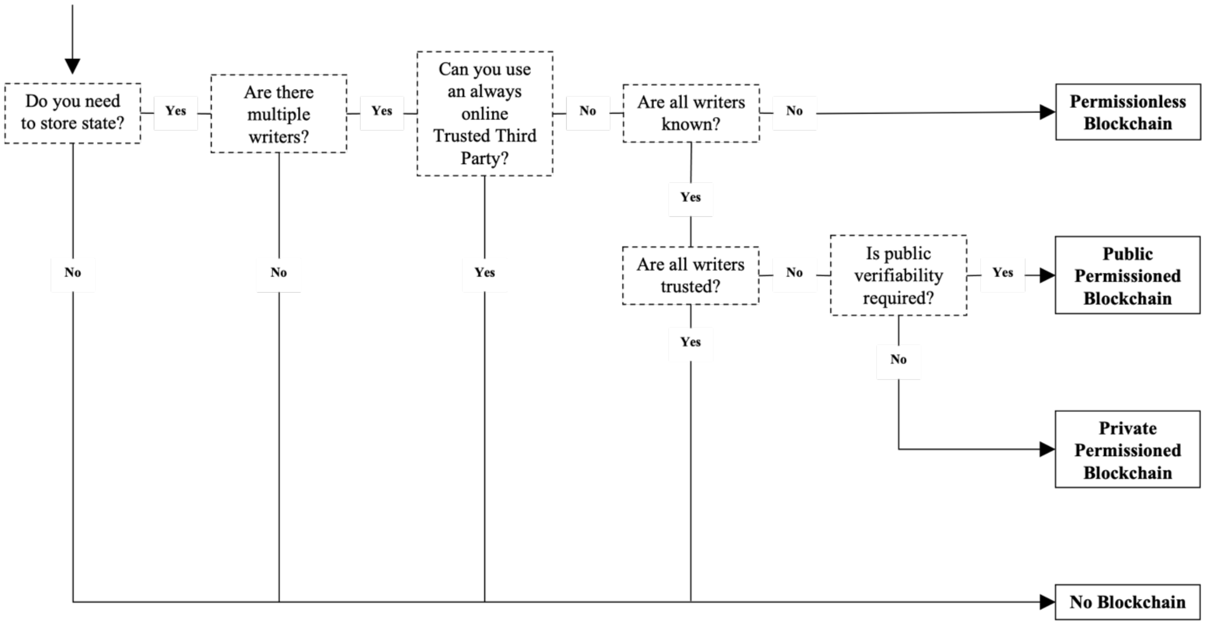
	Supply Chains	**Electronic Health Records**	**Identity Management**	**Stock Market**
Multi-Party	Required	Required	Required	Required
Trusted Authority	Not Required	Decentralised	Not Required	Not Required
Centralised Operations	Not Required	Not Required	Not Required	Not Required
Transparency/Confidentiality	Transparent	Confidential	Transparent	Confidential
Data Integrity	Required	Required	Required	Required
Data Immutability	Required	Required	Required	Required
High Performance	Not Required	Not Required	Not Required	Required
Results	**Blockchain**	**Database**	**Blockchain**	**Database**

Note. Adopted from Lo et al. (2017).

In the same line of thinking, Wüst & Gervais (2018) propose a decision-making flowchart that attempts to determine whether blockchain (as well as which specific implementation) is the appropriate technical solution to a given business problem. Their proposition is structured around six properties that blockchain and more centralised systems provide: verifiability, transparency, privacy, information integrity, data redundancy, and trust. Figure 6 illustrates the flowchart the authors propose, which through a series of questions based on the above aspects, tries to establish if blockchain, and which specific type, is the right approach for a business.

Figure 6.

Blockchain Decision Making Flowchart



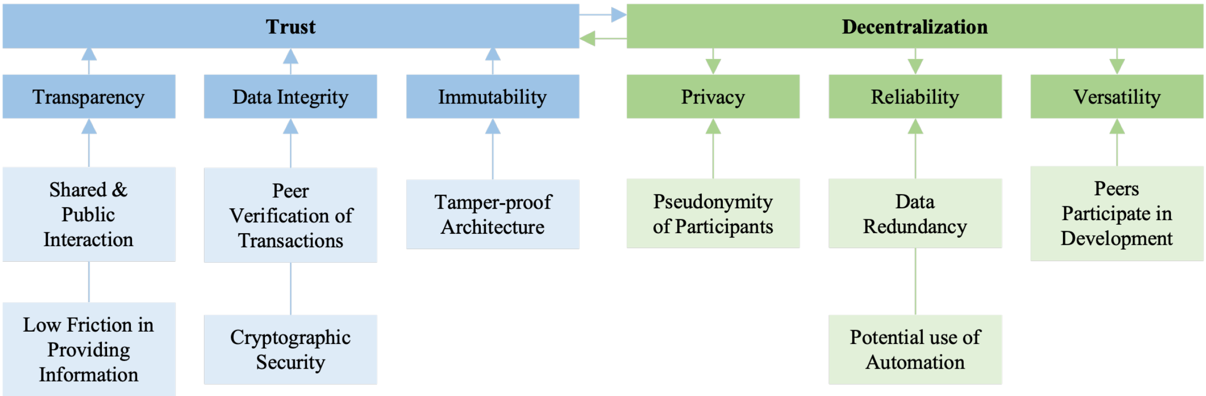
Note. Adopted from Wüst & Gervais (2018).

A case-by-case analysis using this framework on various industries, such as SMC, interbank, international payments and intellectual property, yielded supply chains use-cases as the most prominent area of applications. However, the authors highlight that there are no one-fits-all solutions and that each proposed blockchain application for a specific industry should be examined individually.

Another interesting approach for mapping the properties of blockchain was proposed by Seebacher & Schüritz (2017), who, apart from identifying the main properties of the technology, also examine their interrelations. Figure 7 illustrates the two principal aspects of blockchains: trust and decentralisation. According to the authors, the practice of frictionlessly and openly sharing information with the network provides transparency, peer verification and the use of cryptographic mechanisms for security enables data integrity, and tamper-proof architecture ensures fixity, aspects that overall create the trusted environment that blockchain provides. At the same time, privacy through pseudonyms, reliability through data redundancy and smart contracts, as well as the versatility provided by blockchain, create a decentralised network with minimal points of failure.

Figure 7.

Interconnected Traits of Blockchain Technology



Note. Adopted from Seebacher & Schüritz (2017).

The authors conclude that in the case of blockchain, trust and decentralisation are interconnected. The mechanisms used to establish trust are vital for building a decentralised network where transactions can occur without a trusted third party, while the aspects that create a decentralised network provide the means for users to get involved without any intermediaries. Once again, supply chain applications of the technology seem to attract the authors' attention, especially regarding their potential ability to improve communications, transparency and minimise bullwhip effects (referring to the phenomenon where demand fluctuation and variabilities at the consumer end are amplified as they move further up in the supply chain, creating critical inefficiencies (H. L. Lee et al., 1997).

It's becoming clear, at this stage, that out of several different industries and use-cases of blockchain, there is a clear alignment between the traits and main characterises of the technology and applications that can benefit and improve supply chain management processes, especially regarding transparency and improved communications efficiency - and for a good reason.

2.3 Blockchain for Supply Chain Transparency and Traceability

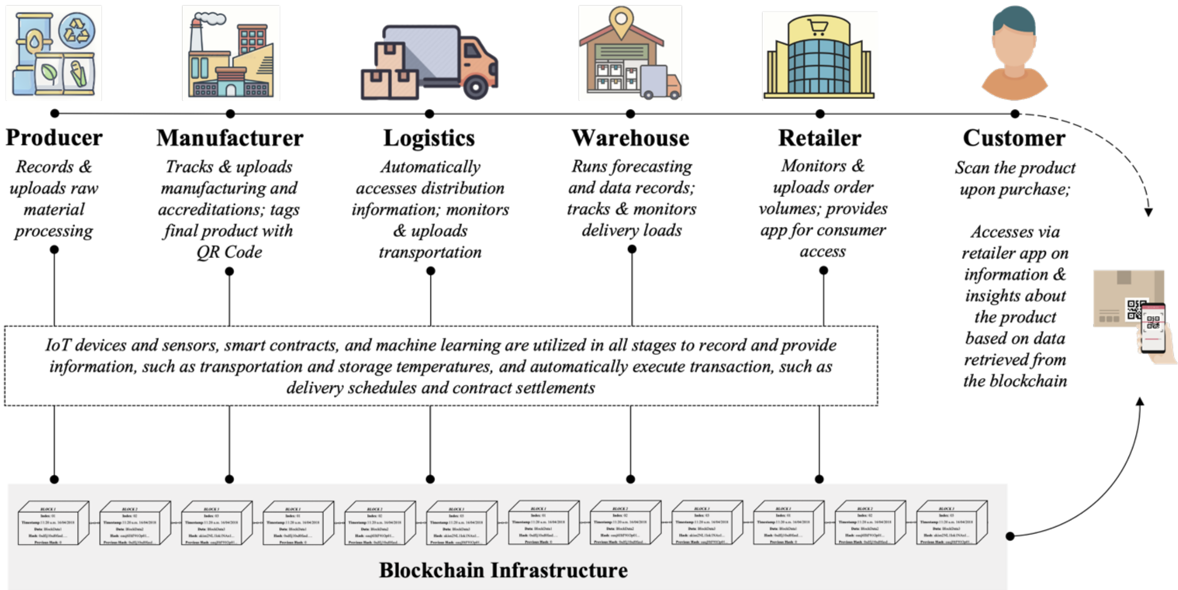
Over the last decades, globalisation and the enormous transfer of manufacturing, goods, and investment, around the world had a profound positive effect on nations worldwide to such an extent that it completely reshaped the economic, political, and social landscape of some countries (Prasad & Babbar, 2000). At the same time, however, global supply chains became exponentially complex and interconnected, making it increasingly challenging to satisfactory monitor processes and consistently ensure standards, not only for governments and regulators but for businesses themselves (Department for Business, Energy & Industrial Strategy & Office for Product Safety & Standards, 2020).

This growing operational complexity in combination with the need for compliance with increased regulatory requirements (e.g., UK Modern Slavery Act (Haynes, 2016); French Duty of Vigilance (Savourey & Brabant, 2021); Dutch Child Labour Due Diligence Act (Enneking, 2019)) and shifts in consumers patterns brought by environmental/ethical considerations (Fraj & Martinez, 2007) and the digital age (Labrecque et al., 2013), increasingly make supply chains susceptible to risks that hinder their overall performance and efficiency. As Manuj and Mentzer (2008) discuss, there are four such main risks global supply chains are facing, namely, supply risks (referring to potential disruptions associated with inbound supply that could cause failures from suppliers or the supply market), operational risks (referring to events, changes in manufacturing or processing capability and changes in technology that could cause the breakdown of operations), demand risks (referring to variations in demand caused by new product introduction changes in consumer habits or new and emerging markets/consumer), and security risks (referring to the capacity of the information system used within a supply chain to withstand external threats).

Using blockchain technologies for supply chain management not only enables efficient communications between different parties in the value chain, but it can also streamline supply chain processes and make production and business practices more transparent (Champion et al., 2018; Hastig & Sodhi, 2020). If we also take into consideration the proposed integration with Internet of Things (IoT) devices for real-time monitoring of information regarding production and transportation (Nikolakis et al., 2018) and the use of smart contracts for the automatic verification and execution of contractual terms (Saberi et al., 2019), these technologies pave the way for what Kos & Kloppenburg (2019) term as hyper-transparency; referring to the digitally-enabled, real-time and often automated mode of data collection and dissemination aimed at optimising operations and governance of global value chains, and hence addressing (or at least reducing) risk exposure and its consequences. Figure 8 illustrates a simplified version of a food supply chain infrastructure build around blockchain, starting at the very beginning with records of raw materials and origin details leading all the way to the end consumer, which can gain reading accesses to the blockchain and verify the provenance of a product.

Figure 8.

A Simplified Blockchain Application in the Food Supply Chain



Note. Adopted from Pai et al. (2018); Laurent et al. (2017).

Another important aspect of blockchain that accelerated its relevance in supply chain applications is that it can significantly enhance trust (Batwa & Norrman, 2021; Malik et al., 2019), in the sense that the benefits of traceability and transparency, as well as the automation of processes these platforms offer, could facilitate transactions between parties without the need for the traditional safeguards that enable trust is such settings. Since trust in supply chain relationships is not a priori, these safeguards are developed and maintained through certain mechanisms. According to Sahay (2003), these can include:

– Cost and benefit analysis regarding the other party's rewards and costs of cheating or staying in the relationship.

- Assessment and forecast of the other party's behaviour and motives (access to information about past/current performance is crucial here because it allows for an informed assessment of the other party).
- Determining the other party's ability to meet its business obligations and commitments as well as follow relevant laws and regulations.
- Developing trust through a transference process, in the sense that it can be transferred from one "trusted source" to another.

Blockchain characteristics such as information sharing, transparency, verifiability, and security can greatly enhance all these mechanisms and promote what PricewaterhouseCoopers (2018) dubbed as trust by design. Hence, one can argue that by utilising blockchain-based systems and creating more open and collaborative supply chains, companies can both mitigate risks as well as improve trustworthiness in their supply networks.

2.3.1 Use-Cases and Applications

It is arguably this potential regarding trackability, transparency and trustworthiness throughout the supply chain that has led to increased pilots and trials from multiple organisations, implementing various versions of blockchain for traceability and provenance purposes. As mentioned in the introduction of this thesis, research by the French consultancy Capgemini (Pai et al., 2018) among 447 companies experimenting with blockchain applications in supply chain management reported that enhancing traceability and transparency were the main drivers behind their venture. More recent data from the Dutch market intelligence platform Blockdata (Knegtel, 2020) suggest that supply chain traceability and product provenance are the most popular blockchain use cases on the Forbes Blockchain 50 list.

There are, of course, many other challenges that modern supply chain management faces, not least finding ways to digitise physical aspects of the supply chain efficiently and reliably. However, the vast majority of blockchain use cases in supply chains attempt, one way or another, to address issues of transparency and traceability. Some examples include:

- Maersk, in collaboration with IBM, has created the TradeLens platform, an open and neutral blockchain-based solution for container logistics and shipment tracking that allows for more efficient and transparent management of overly complex supply chain networks that also need to comply with multiple regulatory agencies (TradeLens, 2020).

- Project Provenance designed a decentralised system in which modular programs deployed on a blockchain will track down the supply chain (producers, manufacturers, registrars, standards, certifiers, customers) with the help of labelling and smart tags in order to enable the connection of physical products with their digital representation (Project Provenance, 2015).
- Modum and the University of Zurich proposed a blockchain-based system for environmental condition and temperature monitoring of drug shipments using in-house developed IoT devices that could be further used in other sectors such as food and beverage and luxury goods (Modum, 2017).
- Everledger has created a blockchain-based system (based on IBM's Hyperledger Fabric) for tracking down the provenance of luxury goods. Although the company started by focusing on enhancing supply chain visibility and digitisation of processes in the diamond industry, it currently offers provenance and tracking solutions for art pieces, fashion, and wine/spirits (Gutierrez & Khizhniak, 2017).
- Food tracking and provenance have also attracted a fair amount of attention. Legacy businesses such as IBM have developed the Food Trust solution, which provides a permissioned blockchain platform for tracking products from farm to store while allowing certain consumers access for verification purpose (IBM, 2019). At the same time, start-ups like TE-FOOD are already utilising their blockchain-based solution for tracking meat supply chains in Vietnam (TE-FOOD, 2018).
- The coffee industry has also seen increased experimentation. Here, legacy supported companies like Farmers Connect (IBM, 2020) and start-ups like iFinca (2020) have released blockchain platforms to transparently monitor a particularly complex supply chain while also focusing on the end consumers and their ability to reliably verify claims on origin and environmental practices.

The vast majority of these applications do not reveal the exact implementation of blockchain they are using, although most of them utilise some form of private permissioned type, with the exception of Modum, which uses the Ethereum blockchain (a public permissionless blockchain) and even issues its own digital coin that is used both for profit sharing reasons as well as for internal voting (it is possible to explore all transaction of the Modum Token on etherscan.io). Nevertheless, whether these blockchain implementations are viable business solutions and will deliver in solving the current challenges supply chains face is yet to be seen since, apart from successful small to medium scale implementations and proof of concept testing, no industry-wide application has been adopted to a more scalable, reliable, or permanent degree. Additionally, the increased trustworthiness this technology promises implies a frictionless economy with minimal uncertainty or risk, and the state of affairs in the blockchain sphere is far from that goal (Ostern, 2018).

This industry experimentation and the increasing number of companies releasing various blockchain supply chain and traceability applications in the market have also prompted governments and regulators to expedite the drafting and deliberation of relevant legislation and regulatory frameworks (Hacker et al., 2019). Although there were, of course, earlier such attempts around cryptocurrencies and digital tokens, with a wide variety of legislative and regulatory approaches around their legal nature and the makeup and responsibilities of digital currency exchanges (a substantial overview of the current global picture is presented in a recent Reuters report (Hammond & Ehret, 2022)) the overall effort around the rest of the technology's ecosystem is lacking.

Such uncharted legislative waters for similar emerging technologies have been encountered in the past, for example, regarding the governance and enforceability of digital signatures and records in the early 2000s and the subsequent drafting and federal-level adoption of the Uniform Electronic Transactions Act (Bosco, 2019). Slowly but steadily, similar efforts have emerged around blockchain in SCM and more commercial applications of the technology. As discussed in a recent report from Foley & Lardner LLP (Casper et al., 2021), states like Arizona and Tennessee are now treating blockchain-secured signatures as electronic ones and have enabled the use of smart contracts for commercial purposes while ensuring their legal validity in a court.

On the same wavelength, Maryland and Delaware have revised their current corporation and company laws to allow for the use of blockchain technologies in creating and maintaining company records (see Isham III, 2019). The Foley & Lardner report (Casper et al., 2021) suggests that moving forwards, regulators should pay attention to blockchain implementations for SMC and product traceability and what contract terms of supply agreements and other commercial contracts need to be adjusted, particularly around areas of governance, confidentiality, force majeure provisions, conflicts, and service level credits.

Despite all this activity on a commercial and legislative level , current academic research on blockchain uses in supply chain management has focused on either the technical infrastructure and possible implementations of the technology (Abeyratne & Monfared, 2016; Feng et al., 2020; Kamble et al., 2020; Li et al., 2018; Mondal et al., 2019; Xu et al., 2019) or are evaluating the feasibility of blockchain applications in aligning with existing drug standards (Scott et al., 2018) or complying with food regulations (Casado-Vara et al., 2018). Even the evaluations and decision-making frameworks discussed earlier, which tried to provide a perspective on industry assessment of blockchain characteristics, have not been empirically tested. Hence, little is yet known regarding which of this technology's main features are most important to industry professionals and decision-makers, how they perceive them, and whether blockchain makes sense for improving and futureproofing their value chains.

What is the industry's stance on information sharing and trust? How do they view the features for tracking provenance and production? Will they be willing to have a more open supply network, and how it will affect managing contracts and multi-stakeholder relationships. Are they willing to share information with lawmakers in an automated regulatory compliance process? Arguably, answering these questions can have an equal, if not more significant, role in determining whether a company needs to explore and implement blockchain solutions in their supply chain than questions on the readiness and capacity of the technical infrastructure or the amount of money invested. Hence, the first research question this PhD thesis will address can be summarised as follows:

> *Which aspects and characteristics of blockchain applications in supply chain management are most relevant to industry decision-makers, and, ultimately, does their organisation actually needs to adopt and implement the technology?*

2.4 Blockchain Traceability from the Consumer Perspective: The Coffee Value Chain

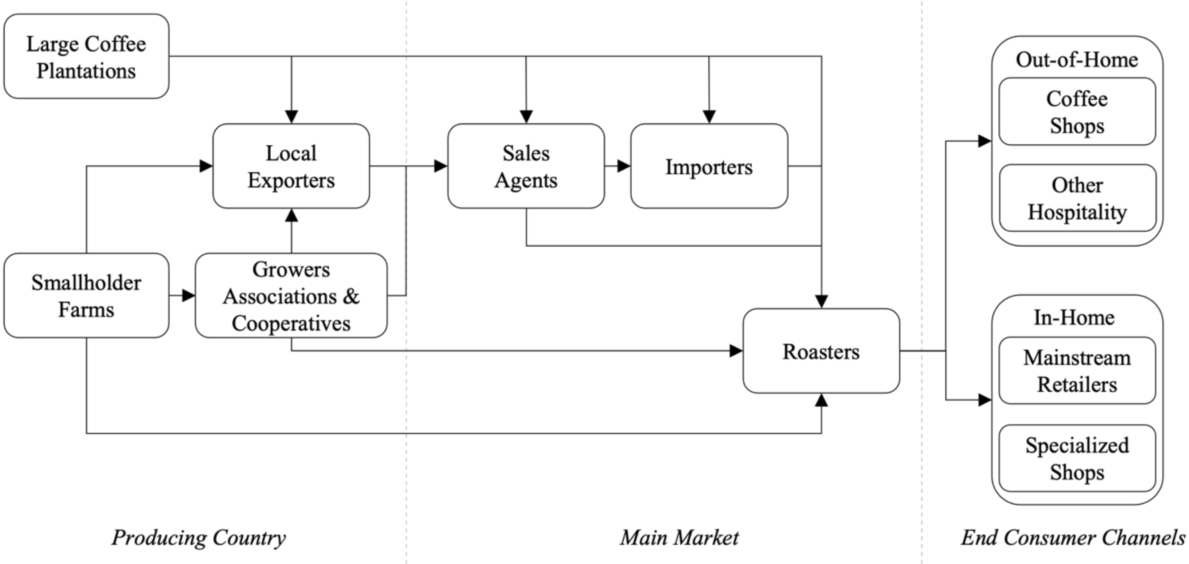
The intricacies of modern supply chains and the increasing concerns regarding delays, disruption, and inefficiencies they cause also extend to the other side of the value chain: the end consumer (Yu & Qiao, 2017). Past incidents of contaminated foods (Peanut Corporation of America salmonella scandal (Leighton, 2016)), dubious business practises and fraud (horsemeat scandal in the EU and UK markets (Agnoli et al., 2016), as well as highly questionable, and in some cases amoral, working conditions (use of slave labour in Brazilian coffee farms (Hansen, 2016)), have jeopardised consumer confidence both in the regulators' capacity to establish frameworks that guarantee food safety and in the industry's ability to ensure and monitor their supply chains transparently (Martinez & Epelbaum, 2011).

It was such instances that made governments realise the need for stricter and more effective rules, which resulted in enhanced regulations and protocols such as the EU General Food Regulation (EC, No 178/2002) and the subsequent requirements for "one step back" – "one step forward" traceability systems (Charlier & Valceschini, 2008). At the same time, these changes compelled the food industry to move beyond compliance with the newly formed legislation in order to restore consumer confidence, either in the form of technological innovation than ensures traceability through the integration of information at all stages of the supply chain or in the form of elaborate certification schemes and quality standards (Martinez et al., 2007). If we also take into account the global emergence of environmentally aware consumers and their demand for "green" practices and credentials (K. White et al., 2019), the importance of transparent and traceable supply chains become even more prominent both for optimal operations management and regulatory compliance as well as for rebuilding consumer trust and confidence.

That is particularly true when it comes to the coffee industry, where supply chains are complex, in terms of processes required to deliver the final product, and with an extensive global network of middlemen, exporters, importers and other intermediaries standing between the farmer and the end consumer (Bradley & Botchway, 2018; Miatton & Amado, 2020) (Figure 9). That complexity, in combination with an industry that is predominantly reliant on extensive paperwork, physical inspections and auditing (Kshetri, 2019), as well as concerns about the environmental impact of growing practices (Panhuysen & Pierrot, 2020) and the fair treatment of farmers predominately located in the developing world (Chiputwa et al., 2015), creates multiple points of failure and enables the falsification of important product information, which in turn can severely jeopardise the end product consumer receive (Pradana et al., 2020).

Figure 9.

Overview of a Potential Coffee Supply Chain and Market Channels



Note. Adopted from Centre for the Promotion of Imports from Developing Countries (2021).

Coffee is a credence good, that is, its product characteristics and claims regarding authenticity, sustainability, and safety cannot be actually verified by the consumer at the point of sale and need to be communicated by the seller/provider or an independent third party (Janssen & Hamm, 2011). For years, the coffee industry has relied on certification schemes and eco-labels to ensure different stakeholders in the value chain of its various properties and practices, and communicate them to the end consumer (Elder et al., 2014; Reinecke et al., 2012). However, researchers have questioned the effectiveness of this practice and the extent to which it successfully delivers on its intended outcomes (Elliott, 2018; Vanderhaegen et al., 2018).

2.4.1 Coffee Certification

The coffee market has exploded over the past decades. Data from the International Coffee Organisation latest development report (2020) suggest that global coffee production has increased more than 60% since the 1990s while the value of all forms of cross border coffee exports has more than quadrupled, reaching \$35.6 billion in 2018 compared to \$8.4 billion in 1991. The sector is only expected to further expand, driven by an increasing demand from emerging markets and even producing countries, which have not been considered major coffee importers up to now, as well as an expansion of retail coffee-based products, such as canned coffee and coffee pods (Sänger, 2018; Voora et al., 2019).

This growth rate, however, comes at a cost for the environment and surrounding climate of the producing areas as well as for the farmers livelihoods, both of which need to significantly expand and adjust to meet this global demand (Vegro & de Almeida, 2020). Additionally, since coffee characteristics such as origin and variety, harvest processes, cherries and green beans handling, roasting profile, and transportation conditions play a crucial role and can significantly alter the quality of the end product consumers receive (Pradana et al., 2020), this expansion also needs to reliably accommodate all these crucial aspects in each stage of the value chain. The exponential growth in coffee demand and production in combination with an already complex supply chain that needs to further expand to accommodate it, means that transparent and reliable information at each stage of the supply network is crucial for an economically viable, socially responsible and environmentally sustainable industry (Miatton & Amado, 2020; Smith, 2018), that can harness this growth while fairly distributing its benefits throughout the entire coffee value chain.

Up to this day, certification of coffee, referring to a wider family of voluntary range of standards (economic, environmental, social etc.) set by independent bodies against which producers are audited and certified (Bray & Neilson, 2017), has been one of the key tools in order to ensure the quality and sustainability of coffee production (Basu et al., 2018; Elder et al., 2014; Van Loo et al., 2015). In fact, the coffee industry has been one of the early pioneers in sustainability certifications and agricultural commodity eco-labelling (London, 2012; Reinecke et al., 2012). Although for years certified coffee remained a niche market, it has seen exponential growth during the past decade with the latest estimated suggesting that at a farm level, 55% of the total volume of global coffee production follows some form of standards (Panhuysen & Pierrot, 2020), indicating that sustainability certifications have entered the mainstream coffee market (Centre for the Promotion of Imports from Developing Countries, 2021).

As Elder et al. (2014) point out, the first coffee sustainability certification systems emerged in the 1970's and 1980's as a result of the prior fair-trade movement and the merger of various other organic movements into centralised organisations (such as the International Federation of Organic Agriculture Movements (Paull, 2010)) while product labelling of sustainable coffee was utilised as a tool to help competing with mainstream market products. Later, and as world-wide standardised certification systems and procedures started to form, labelling also played the role of ensuring consumers that the environmental, social, and economic aspects of coffee production that each certifications protocol follows have been meet (Raynolds, 2002).

Today there is a plethora of various standards and certifications, each covering a different aspect(s) of coffee production and following different protocols and procedures to ensure compliance (Kolk, 2013). For example, organic schemes focus mostly on farming practices with less attention paid to social or economic aspects of coffee production, while fair trade schemes cover mostly working conditions and fair treatment of producers and their families and put less emphasis on environmental considerations (Van Loo et al., 2015). At the same time, third-party market driven schemes like UTZ and Rainforest Alliance (now merged; see Rainforest Alliance (2021)) have adopted a more holistic approach in their standards addressing a wider range of economic, social, and environmental issues along with supply chain transparency (Bray & Neilson, 2017). Conglomerates such as Kraft and Nestle have also entered the "certification arena", forming the 4C Association that promotes sustainable practices in coffee production utilising an internal monitoring system that is directly integrated into their business model (Elder et al., 2014), while popular coffee brands like Starbucks and Nespresso have followed a similar path forming schemes like C.A.F.E (Coffee And Farmer Equity) Practices and AAA Sustainable Quality , respectively (Potts et al., 2014).

The continuous growth and adoption of certified coffee could lead one to believe that certification schemes are successful in achieving their goals, be it upholding environmental and production standards or improving and uplifting quality of life and working conditions for producers. Although the positive impact of these schemes on economic, social and environmental aspects of coffee production is documented in the literature (Haggar et al., 2017; Loconto & Dankers, 2014; Oya et al., 2018), several researchers and organisation have increasingly questioned their effectiveness, and whether they truly deliver on their intended outcomes (Giovannucci et al., 2008; Miatton & Amado, 2020; Panhuysen & Pierrot, 2020), with some even characterising the uptake in coffee sustainability scheme adoption as a "green wash" and an attempt to gain access to emerging coffee markets and new consumer segments (Goodman, 2010). Today, the existence of multiple certifications has oversaturated the market and, in several cases, overwhelm producers that try to meet multiple requirements for different certifications (Souza Pião et al., 2020) as well as confuse consumers by creating choice overload and label fatigue while undermining notions of trust and validity they place on them (Basu et al., 2018).

To an extent, certifications are a market-based approach of assigning value to certain product attributes and incentivise farmers to apply sustainable production method (Millard, 2011) creating, in this way, what Lipschutz (2005) described as a social contract between producers and consumers. However, to what degree this contract delivers on its terms for both these parties is questionable and seems to vary depending on the certification/standards used. For example, coffee products with organic and fair-trade certifications generally have higher price premiums but at the same time require higher implementation costs to obtain the certification, which results in minimal economic gain (Elliott, 2018). A cross country study by Méndez et al. (2010) also found the direct financial effects of certification to be minimal, especially compared with the positive outcomes on aspects such as health and education that a cooperative membership provides. Even long-term advocates of fair-trade coffee, such as the president of the specialty coffee association of America, has questioned the relevancy of certifications and their ability to uphold the claims they make to consumers (Haight, 2011). More importantly, Samper & Quiñones-Ruiz (2017) suggest that sustainability schemes face difficulties in growing and expanding their operations in order to address the supply chain complexities a growing coffee industry brings and suggest it is time to re-evaluate the existing model.

2.4.2 Blockchain Transparency and Traceability

One of the main issues when considering the effectiveness of these schemes is their ability to provide transparent and reliable information about the processes followed throughout coffee production. This is further hindered by the fact that each scheme conducts its audits separately while the findings are not shared between different parties but instead remain in data silos (RSB & Provenance, 2018). Calls for a more open and reciprocal approach in the industry, with transparency and traceability in all directions of the supply chain at its core, have long been voiced in the literature (London, 2012), and for a valid reason. The incorporation of a well-established, decentralised traceability system not only solves what Levine (2017) describes as the “messaging problem” in supply chains (referring to communication inefficiencies between parties) but can provide benefits on regulatory compliance, better production and inventory management, improved handling of food crises and increased marketability of goods (Aung & Chang, 2014).

The importance of food traceability came under the spotlight, particularly following the aforementioned series of food scandals over the last decades that have shaken consumer confidence and forced regulators and companies to take immediate steps in order to ensure the quality and safety of their products (Martinez & Epelbaum, 2011). Although a variety of definitions for traceability have been proposed in the literature, from an agricultural perspective, the term refers to the systematic process of gathering, storing, updating and utilising information related to every step of the supply chain in a way that provides assurance to all stakeholders about the origin, production, and distribution of a product and allows for efficient crisis management in the case of quality breaches through forwards and backward tracking ("one step back" – "one step forward" systems) (Charlier & Valceschini, 2008; Opara, 2003). In the same line of thinking, the UK Food Standards Agency (2019) defines traceability as: "The ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution" (p.8). From the perspective of the coffee industry and the credence qualities of its products, traceability might also include several labelling tools that allow buyers, which are often removed from the producer, to safely identify where a batch came from and what steps were followed in its production (Smith, 2018).

According to (Opara, 2003), an intergraded and effective agricultural/food supply chain traceability system is comprised of six elements:

- Product traceability refers to the ability of establishing the physical location of a product through any stage of the supply chain, allowing both efficient inventory management and information sharing with stakeholders and consumers.
- Process traceability describes the sum of all activities and specific processes that occurred during growing/farming and postharvest and can include environmental, mechanical, and chemical factors as well as potential contaminants.
- Genetic traceability contains details regarding the genetic composition of the raw materials used to create a product, including origin, type, and any genetically modified components.
- Input traceability refers to the specific agricultural input such as fertilisers, feedstuffs, chemical sprays, or any additives used to store and transport other raw materials.
- Disease and pest traceability tracks and traces pests and potential pathogens that can contaminate both raw materials and products throughout the supply chain.

- Measurement traceability refers to the quality and accuracy with which traceability information is recorded, including both the type and condition of equipment as well as alignment with formal and accepted reference standards and regulations.

To this day, traceability has been achieved through the use of Enterprise Resource Planning (ERP) systems, which allow for the integration of primary business processes with tactical management of product and supply chain data (Hollands et al., 2019). However, since modern businesses require the collaboration and coordination of global supply chain networks that, more often than not, span multiple jurisdictions and involve numerous actors, researchers have pointed out the shortcomings of ERPs, especially regarding their ineffectiveness to integrate with other systems and applications (Doedt & Steffen, 2011; Kähkönen et al., 2015). As a result, various solutions to this issue have been suggested in the literature, proposing systems that consist of joint infostructures, coding standards and integrated databases across multiple supply chain networks (Trienekens et al., 2012).

Against the backdrop of such evidence, the coffee industry has turned its attention to emerging technologies, like blockchain, in order to find ways to regain consumer trust while also streamlining its own operations and aligning with government regulation (Thiruchelvam et al., 2018). Technically, blockchain is another form an inter-organisational ERP, however, as Kumar et al. (2020) discuss is inherently different in three ways. First, it allows for a multilateral decentralised network of communications and settlements. Second, it provides greater integrity and security through the tamper-proof nature of the ledger. Finally, it allows for automated agreement execution and other business logic through the use of smart contracts.

As I discussed, the ability of these technologies to enhance tracking and transparency, offer better scalability, and provide robust security and fault tolerant records, delivers not only solutions for regulatory compliance, corporate and investor assurances, and grower/farmer uplift (Kshetri, 2018; Wang et al., 2019), but also a unique opportunity for consumers to access data and information not available to then until now (Boukis, 2020) and, ultimately, move coffee from a credence to a search good. Additionally, since current coffee traceability certifications only cover specific aspects of coffee production, blockchain can potentially allow multiple elements in Opara’s (2003) framework to be managed under a single platform.

There are already a few such applications released in the mainstream market. Coda Coffee partnered with Betx360 to create the first blockchain traced coffee from bean to cup using Bext360's machines to sort coffee cherries and beans and record them in the company's blockchain platform (Youngdahl & Hunsaker, 2018). Japanese coffee manufacture UCC also partnered with Farmers Connect (UCC Coffee, 2020) for one of its coffee brands, using the latter's blockchain platform to store and validate data from all parties involved in their supply chain, while their *"Thank My Farmer"* platform goes a step further by offering consumers the opportunity to support farmers and producers directly. Another example is the one of Dutch non-profit organisation Fairfood, in collaboration with speciality coffee importer Trabocca, which has proposed a similar blockchain-based platform exploring the added value of traceability, particularly for improving farmers quality of life (Brunt & da Costa Guimaraes, 2020).

These business cases highlight some of the positive aspects transitioning to blockchain-based solutions can have in ensuring the quality of coffee and assuring for the sustainable, economic, and social credentials of its production. As Miatton & Amado (2020) suggest, blockchains provide a robust platform upon which the coffee industry can build transparency in its complex, opaque and often closed value chain. What is more, data availability offered by blockchain-based systems can go beyond production audits, optimised supply chain management, and product tracking. Since most supply chain data is inaccessible, these systems can provide consumers with traceability information, unviable to them up to this point (Schlegel et al., 2018).

2.4.3 The Consumer Perspective

Earlier research has revealed that such traceability systems can decrease information asymmetry and increase consumer confidence in food safety (Kher et al., 2010). Furthermore, the information provided by these systems has been found to reduce consumer uncertainty for sustainable product attributes and enhance purchasing intentions (Choe et al., 2009). Credible traceability information also enhances consumer trust and their confidence to make their own judgment about food safety (Lam et al., 2020), while it can positively affect their willingness to pay (WTP) a premium for a product (Dopico et al., 2016; Hou et al., 2019), although some variation exists between consumer categories (Nie & Luo, 2019). The same is true for coffee certification, for which consumers are generally more willing to pay a premium, but the magnitude might depend on the specific label (Howard & Allen, 2010) and the profile of the consumers themselves (Van Loo et al., 2015).

Apart from its effect on consumer perception, trust and WTP, the proliferation of traceability information seems to be in line with a rising consumer interest towards transparent and sustainable practices. Data from the European Institute of Innovation and Technology Food Trust Report (EIT, 2020) across multiple European Union countries indicate an increased consumer demand for "farm to fork" transparency and more informative product labelling. The rise of the green consumer, primarily upon millennials segments (K. White et al., 2019), also exudes the same sentiment towards traceability qualifications (Kshetri, 2018) and further suggests the need for new ways of effectively disseminating that information to them (Hahn-Petersen, 2018). At the same time, a recent survey from energy firm E.ON (2020) suggests that even the COVID-19 pandemic has accelerated these trends and altered consumer purchasing habits, with more than half of participants indicating that clear and transparent environmental credentials of a product or a service are as equally important as their price.

Despite the numerous food scandals and reduced levels of consumer trust, the mandate for more transparency in business practices and production, and the positive aspects of traceability information, research suggests that the cognition level of consumers regarding the concept of traceability is low (Hansstein, 2014; Martinez & Epelbaum, 2011). A plausible explanation for that limited knowledge might lie in the industry's practice of utilising certifications logos and eco-labels to convey the existence and benefits of a robust traceability system. As Holleran et al., (1999) discussed, the absence of a way for consumers to directly observe safety and quality systems makes certifications and other assurances the only tools in the industry's arsenal to convey that information to them. Ultimately, the credibility of these schemes in the eyes of the consumers depends on whether they trust their claims and the processes that ensure them (Yokessa & Marette, 2019).

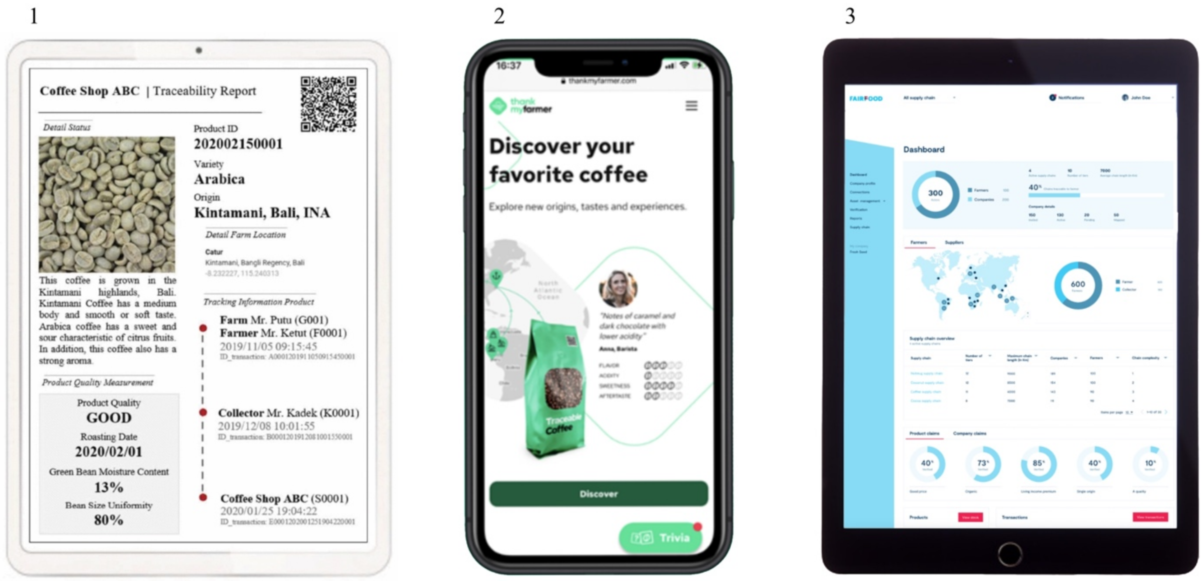
Although research has indicated that such certification logos could have a positive impact on consumers' purchasing intentions (Batte et al., 2007; Johe & Bhullar, 2016) and potentially reduce feelings of uncertainty (Chen & Huang, 2013), the labels on the product convey little to no information about production conditions and processes or evidence that support their observance (Sander et al., 2018). Moreover, misleading marketing campaigns, which rarely acknowledge what is not covered by certifications and labels, lead consumers to often create incorrect expectations about their attributes (Daugbjerg et al., 2014). If we also add the multiplicity of certifications that are currently in the market and the choice overload and confusion they cause to consumers (Glasbergen, 2018; Yokessa & Marette, 2019), the need for clear and concise information becomes even more prominent and could provide consumers with an improved understanding of traceability and, consequently, increase their awareness. As a matter of fact, research from Atkinson & Rosenthal (2014) indicated that consumers prefer detailed labels that contain specific information about any environmental claims made, rather than a simple logo or graphic that merely implies their existence.

A traceability system based on blockchain technologies will allow consumers to gain "reading access" to its records by using their mobile phones to scan a Quick Response (QR) code placed on the product. This action will lead them to a website where they can track the entire product's journey throughout the supply chain and access information on origin, production, transportation, and packaging. In the academic literature, Pradana et al. (2020) suggested such a blockchain-based traceability system for the coffee agroindustry, in which all the technical and complex information about production and standards, as well as the product's journey, are presented to consumers in a timeline format they can access by scanning a barcode on the product (No. 1 in Figure 10). The coffee industry has also adopted similar approaches. For example, companies like Farmer Connect and Fairfood (No. 2 - 3 in Figure 10), discussed earlier, utilise similar platforms and visualisation approaches (Fairfood utilises a dashboard format) to convey complicated coffee supply chains data to consumers while adding unique features like the *"Thank My Farmer"* option and additional information and bios for producers.

Despite the increased market interest in blockchain solutions for product traceability and the continuous, albeit relatively slow, emergence of applications that employ them for provenance purposes, research on what these new platforms mean for the end consumer and how they compare with existing systems and practices in the market is limited (Boukis, 2020; Schlegel et al., 2018), although emerging findings suggest a potentially positive impact. For instance, Sander et al. (2018) reported that using a blockchain-based traceability system for tracking meat products positively influenced consumers' purchasing decisions and quality perception, while the additional information provided was highly welcomed. Similar findings were presented by Nie & Luo (2019) when exploring the use of blockchain traceability in an e-commerce platform, with variables such as trust, perceived benefit, familiarity, and perceived risk having a positive effect on participants' intention to purchase products with such a traceability system, whilst aspects such as third-party certification, platform reputation, and government supervision influenced their trust towards the system.

Figure 10.

Blockchain Traceability Applications for Coffee



Note. 1. Pradana et al. (2020) Traceability Report; 2. Farmer Connect *"Thank My Farmer"*; 3. Fairfood Dashboard.

In spite of these emerging findings, research on what these new blockchain-based traceability systems imply for the consumer and the influential factors behind their intentions to purchase a coffee product bearing them is non existing. At the same time, no work has been done on examining how blockchain traceability compares in the eyes of the consumer with other certifications and industry practices for coffee products; an area that is generally understudied even for conventional coffee certifications (Basu et al. (2018) discuss how studies examining consumer decisions and perceptions about different coffee certifications is "non-existing").

The question of how consumer preferences for coffee products might be influenced by their perception and awareness of these different systems is of great importance not only for coffee certification bodies but for all actors in the coffee supply chain. Answering such a question will bridge the research gap in the literature and provide a starting ground to further establish how consumers perceive these new systems while also helping firms explore how incorporating such technologies might alter the consumer experience and generate new streams of value for all parties involved. Hence, the second research question this PhD thesis will address can be summarised as follows:

> *How consumer perceive blockchain applications for coffee traceability, what are the influential factors determining their intentions to purchase products that utilise them, and how they compare with existing traceability certifications in the market?*

2.5 Conclusions

The aim of this literature review chapter was to step back and decipher the gridlock blockchain applications currently find themselves in by providing an overview of the origins of blockchain and its basic features as well as its implementation in SCM for transparency and traceability purposes. This endeavour led to the first research question, which addresses industry consideration around blockchain applications and the actual need for companies to adopt them. The attention was then turned to the end consumer and blockchain application for traceability in the coffee value chain. The current state of the coffee certification market was first examined, followed by an exploration of the current solutions offered by blockchain and its implications for the end consumer. This process led to the second research question, which addresses consumer preference for blockchain traceable coffee and compares it with existing solutions in the market.

As it is becoming evident from the two main research questions, this thesis strives to address both the element of technology adoption and relevance from the industry side, as well as explore and understand the perspective and preferences of the end consumer. This approach is not merely an attempt to ensure that views absent from academic research are equally represented and this literature gap is filled, but an effort to address the stagnation in blockchain application growth and adoption by examining the two sides of essentially the same coin.

In the next chapter, I will further elaborate on the choice of such research design, expand on the two research questions, and provide an overview of the methodologies used in the three studies and the rationale behind them.

3 Research Design and Methodological Choices

Since the early stages of my PhD, I realised that a multifaceted approach would be needed in order to investigate such a new and disruptive innovation as blockchain. Although, at that time, I had not decided which specific application of this technology would be the focus of my research, it was apparent that examining both industry evaluations as well as consumer perceptions would provide a solid foundation for my research design and overall argument. This notion was further fostered by the fact that this PhD is part of the Horizon Centre for Doctoral Training, which places interdisciplinary research that combines a user-centred approach through close industry involvement at the heart of its PhD programme[1].

Another reason why such a research strategy is beneficial for the study of this topic is that, as mentioned earlier, the vast majority of the literature regarding the utilisation of blockchain and distributed ledger technologies for supply chain management, in general, and product provenance and traceability, in particular, has focused on the technical (Kumar et al., 2020), economic (Fan et al., 2020), and sometimes operational (Babich & Hilary, 2020) aspects of the technology. Little attention has been given both to how the unique properties that blockchain introduces will affect its design, implementation, and overall adoption and almost no focus has been paid on what are the implications for one of the most significant stakeholders of these applications, that is, the consumer (Schlegel et al., 2018).

As several media and industry figures have suggested, blockchain is a solution looking for problems (Bull, 2017; Frederik, 2020) or, as Glaser (2017) puts it, a technology looking for use cases, a view that can justify, to a certain extent, the lack of market-wide adopted applications. Therefore, examining fundamental aspects of this technology around SCM and product traceability while considering both sides of the spectrum will also play an important role in realising where this technology's potential lies and possible ways to actualise it.

It was also crucial that this multifaceted approach used to structure the thesis research questions also expanded in the methodological choices used to explore them. There is a plethora of literature highlighting the rise and usefulness of multi and mixed-method research (combining

[1] More information about the Horizon Centre for Doctoral Training can be found at: https://cdt.horizon.ac.uk

both qualitative and quantitative approaches) in general (Almalki, 2016; Doyle et al., 2009) and in a variety of different fields within business research (Cameron & Molina-Azorin, 2011; Molina-Azorín & Cameron, 2015), in particular. Adopting such an approach should provide not only more comprehensive and granular insights into the questions at hand but also balance out the limitations of different methods and enhance confidence in the findings. That is an important point, given that the current thesis explores a new and relatively unexplored topic where data diversification can be beneficial, if not necessary.

As discussed later in this chapter, although I strived to abide by the abovementioned notion of multi/mixed methods research to explore blockchain applications in SCM and product traceability, the COVID-19 lockdowns caused a substantial amount of disruption which required continuous adjustment in the methodological approach and decision-making. Although the multistakeholder approach and the research questions remained unaffected by the disruption of the pandemic, the methods utilised to collect the necessary data to answer them had to either be adopted (semi-structured interviews to an online qualitative survey) or completely redesigned (in-person interactive workshops to an online quantitative questionnaire) as a result of the availability of participants and the inability to conduct face-to-face research.

In the rest of this chapter, I will further elaborate on the formulation of the two research questions and present the framework they were based on (3.1). I will then provide an overview of the methodologies utilised for each of the three studies conducted along with the reasoning behind them (3.2 – 3.4). The impact of the COVID-19 pandemic on these choices will also be addressed (3.5).

3.1 Formulating the Research Questions

Balancing the perspective of two different stakeholders has been a tricky process, especially at the beginning of my work. Interestingly, fellow PhD colleagues working on parallel topics, such as robotics adoption, have also expressed during discussions their predicament in establishing the context around research that includes both the industry perspective on adoption and end-user preferences. For this reason, I utilised Risius & Spohrer's (2017) blockchain research framework to establish a multiagent context for my research and develop the main questions this thesis addresses. Their work builds on previous guidelines proposed by Aral et al. (2013) that successfully generated a solid research stream in the related area of social media business transformation. The authors' revised framework proposes three groups of activities at four levels of analysis that blockchain research could be structured around (Table 2).

Table 2.

Blockchain Research Framework and % of Research Distribution

Level of Analysis	**Activities**		
	Design & Features	Measurement & Value	Management & Organisation
Users & Society	5 %	4 %	4 %
Intermediaries	10 %	5 %	5 %
Platforms	20 %	5 %	9 %
Firms & Industries	8 %	13 %	12 %

Note. Adopted from Risius & Spohrer (2017).

The level of analysis of the framework denotes different stakeholder perspectives. Users and society refer to the individuals that transact through and/or interact with blockchain SCM applications while also including the behavioural and societal consequences of the technology. Intermediaries involve various applications and providers hosted within a blockchain network and connect service providers with service consumers; in other words, the middleman. The platform level covers different types and implementation of blockchain technologies as well as potential cross-platform interactions. Finally, firms and industries involve those companies and organisations that are implementing blockchain solutions and/or are likely to be affected by them and the potential business and governance models the technology introduces.

On the other side of the framework, the authors propose three levels of activities. Design and features refer to different characteristics of blockchain, their effects, and how these aspects can be used to design different applications in order to achieve specific outcomes and goals. Measurement and value describe the added value the technology introduces and how it can be captured either regarding its competitive advantage or the existing industries it disrupts. Finally, management and organisation refer to the governing decision-making processes within blockchain environments as well as the strategies and tactics employed by actors within these systems.

When analysing the existing literature through the lens of their framework (Table 2), Risius & Spohrer (2017) point out that on the firm and industry level, the design and features aspect of blockchain has attracted the least attention in the literature. At the same time, aspects of value measurement and management have also received limited research contributions both on the users' level as well as the intermediaries and platforms. That is in line with my literature review, which also highlighted the focus on the technical development of blockchain while ignoring other vital research areas.

Hence, based on my background and research interests, the examination of the current state of blockchain application in SCM as well as the research gap identified in the literature, this PhD focuses on the design and features aspect of the organisational level and at the value measurement aspect for users and society. Table 3 summarises the research questions developed in my literature review within the proposed framework.

Table 3.

PhD Research Questions

Activities	Level of Analysis	Research Questions
Design & Features	Firms & Industries	Which aspects and characteristics of blockchain applications in supply chain management are most relevant to industry decision-makers, and, ultimately, does their organization actually needs to adopt and implement the technology?
Measurement & Value	Users & Society	How consumer perceive blockchain applications for coffee traceability, what are the influential factors determining their intentions to purchase products that utilise them, and how they compare with existing traceability certifications in the market?

3.2 Study 1: Blockchain Beyond the Code Console - The Industry Perspective on Blockchain Applications for Supply Chain Management

Even though several organisations have conducted survey work in exploring industry attitudes on blockchain, with some even doing so on an annual basis (e.g., Deloitte's Global Blockchain Survey), the focus of that work has primarily been on either technical and operational considerations or the financial and investment aspects of the technology. That is also the case with the very limited industry surveys conducted in SCM, with Capgemini's (Pai et al., 2018) report being the only one to involve industry decision-makers and not merely examine and analyse databases and case studies. The same holds true in the academic literature, where only very recently research emerged that examines other aspects of blockchain, with Friedman & Ormiston (2022) conducting a series of interviews with stakeholders in the food supply chain, exploring the role of the blockchain as it relates to enhancing sustainability practices and how it aligns with the industries overall sustainability philosophy. As Kumar et al. (2020) suggested, in order for blockchain adoption in SCM to go mainstream, several questions around trust, data, collaboration, and governance need to be addressed.

Hence, in designing the survey that was used to answer my first research question, I focused on a) the decision-makers perspective on the implications of the most significant features of blockchain in supply chain management and b) the need to implement the technology in their business case. The first phase of this design included a series of questions that covered the industry's views and attitudes on four fundamental aspects of blockchain implementation in SCM, as were identified in my literature review. These aspects are tracking provenance and production, managing contracts and multi-stakeholder relationships, trust & "trust-free" applications, and regulatory compliance. For each of these aspects, a set of questions were developed that covered topics such as:

- The company's willingness to provide end consumers access to its traceability system for verification purposes.
- Views on data and information sharing as well as closer collaboration both internally (networks of partners/suppliers) and externally (wider industry).
- The importance of trust in business-to-business transactions and their overall perspective on the implications of blockchain-based trust on their industry.

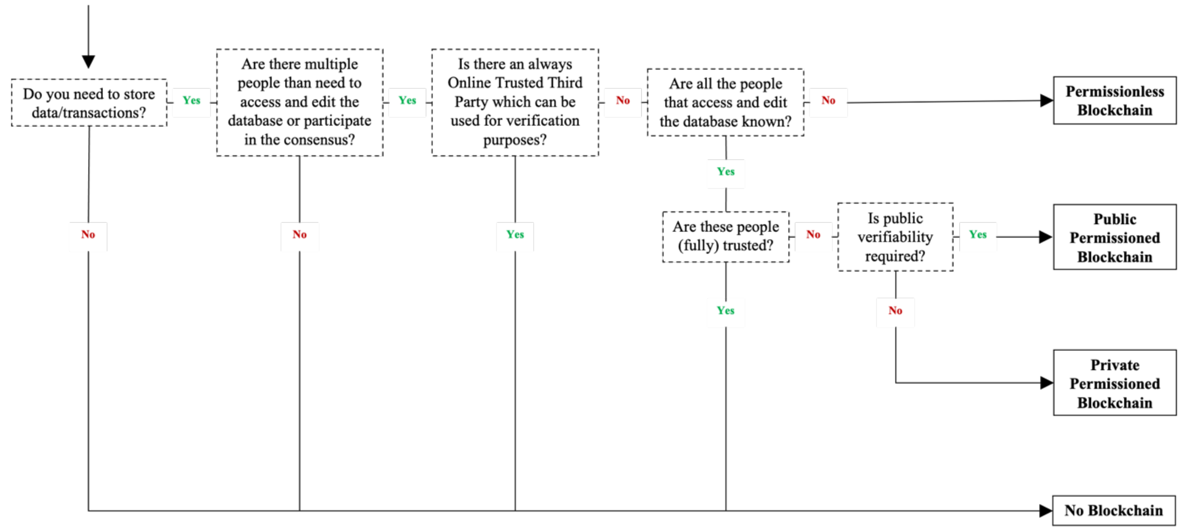
– Willingness for closer collaboration and information sharing with regulators.

The complete set of questions will be further analysed in the next chapter (Chapter 4) when discussing the findings of the first study.

The second phase of the design included exploring the actual need for adopting a blockchain solution for their supply chain. Since the blockchain evaluation frameworks discussed earlier have not been empirically tested, I utilised Wüst & Gervais's (2018) proposed model in order to achieve that aim. The main goal of this process is to assist businesses and organisations in whether blockchain (and which specific implementation) is suitable for solving a specific business problem they face. Figure 11 illustrates the decision-making flowchart used in my research, along with the questions asked at each step of the process, which have been modified to fit my specific research focus. Participants start at the top left corner and move along the chart based on their responses. The process ends once participants reach one of the four outcomes on the right side of the chart.

Figure 11.

Blockchain Decision Making Flowchart (Modified Version)



Note. Adopted from Wüst & Gervais (2018). A full-sized version can be found in Appendix 1.

Apart from these two main elements, the rest of the survey also included a number of general demographic questions regarding participants' company/organisation and their specific role/position. It also contained a series of questions, more in line with the existing survey work conducted, regarding their industry and how blockchain relates to it. This included questions about the challenges their industry is currently facing, their readiness for blockchain technologies, the use cases and implementations they are considering, evaluation metrics/criteria and time frames they are going to use for measuring business case results, their willingness to participate in industry-wide blockchain consortia/networks, security concerns, and potential regulatory challenges. For these questions, participants were required to select from a range of preselected answers (in some cases being able to select more than one). These questions were generated based on several existing industry-wide surveys (Pawczuk et al., 2019; Vadgama et al., 2019) as well as based on the areas of interest that emerged from my literature review.

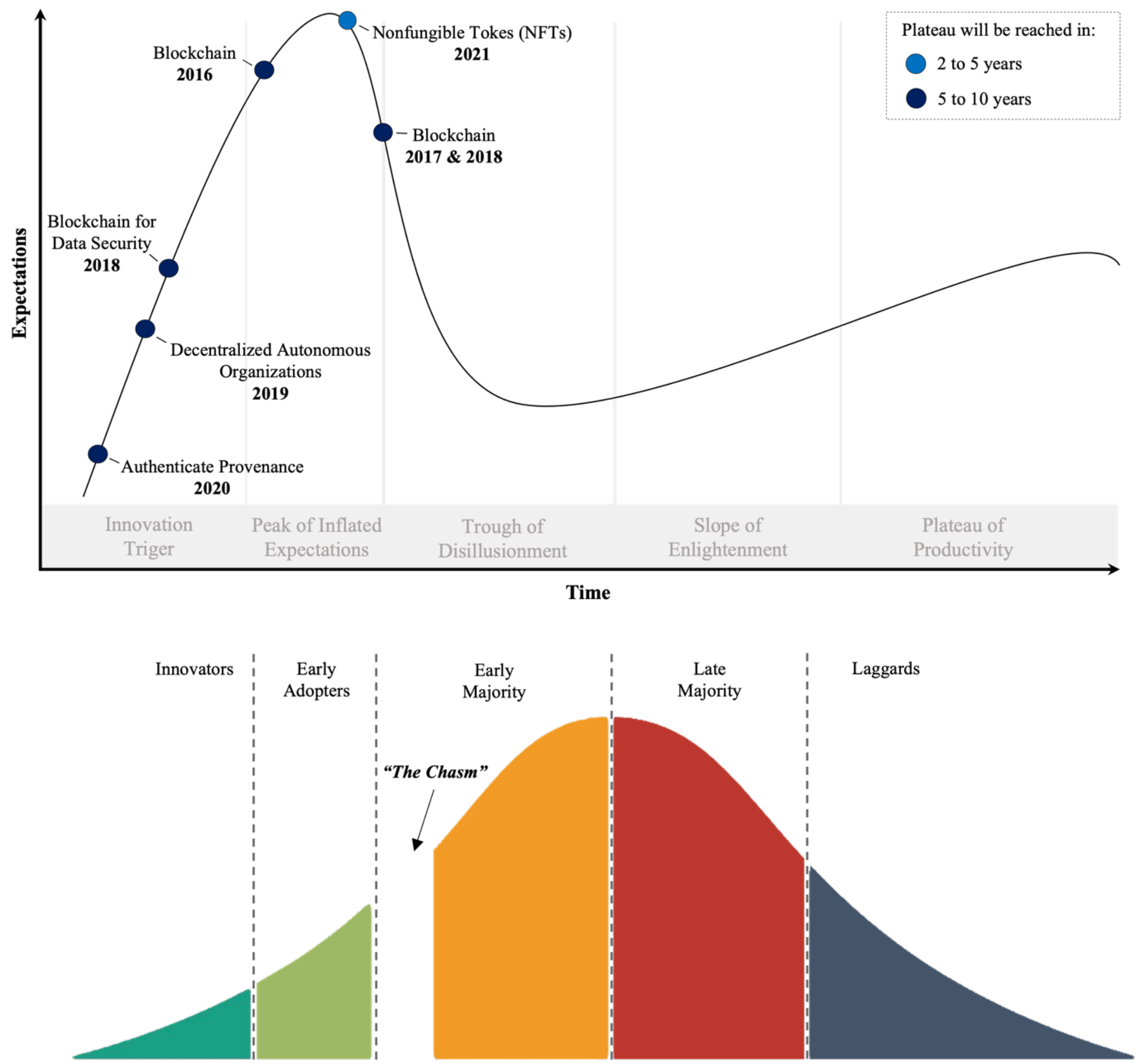
Another essential aspect of this study was targeting the right participants that could provide useful and valid insights into blockchain implementations in supply chain management. This implied not just a sufficient level of knowledge around the technology, but a degree of involvement in a project, regardless of its stage (research – trial – ready to use). I demonstrated in the introduction how blockchain's fluctuation in the Gartner's Hype Cycle suggests that the technology has entered Moore's chasm (2014), which denotes an innovation's leap from an early to a more mainstream market. Figure 12 illustrates this view while also pinpointing the potential target sample for this study, that is, innovators (groups that pursue and implement early technologies even before a "formal" market is formed) and early adopters (groups that get involved with the technology at its early stages).

In the initial stages of my PhD, I attempted to conduct a series of exploratory interviews, broadly based on the concepts included in the survey and targeted mainly at start-ups and companies developing blockchain platforms and systems (innovators). However, positive responses to interview invites were non-existing. Even attending various industry workshops and conferences did not prove enough to attract such a sample. Interestingly, in communications with a few start-ups, there was an evident reluctance in participating, merely attributed to the company's small scale and limited resources from being in the early stages of their development.

With that in mind, the distribution of the final survey was open to start-ups, established companies and broader organisations that are utilising blockchain in supply chain management. The aim was to recruit mid to senior-level employees from the UK and EU markets involved, in some role, with blockchain application development. The survey went online in late February 2020, and several channels were used for its distribution. Apart from emailing the survey to several companies directly, I also contacted research centres at the university with an industry network as well as business consortiums (e.g., Supply Chain Sustainability School, Retail Blockchain Consortium), asking them to forward the survey within their networks, while my external partner also assisted with recruitment. Unfortunately, the first COVID-19 lockdown came right after the launch, and since it drastically changed companies' priorities, responses were scarce for the first few months, and the survey had to be extended to the end of that year's summer in order to reach a sufficient sample size. Chapter 4 will further discuss the methodology of this study and its findings.

Figure 12.

Gartner's Hype Cycle and Moore's Revised Technology Adoption Life Cycle



Note. Adopted from Panetta (2016a, 2017a, 2019a, 2019c, 2021a, 2021b) (Upper) and Moore (2014) (Lower).

3.3 Study 2: Examining the Influential Factors of Consumer Purchase Intentions for Blockchain Traceable Coffee Using the Theory of Planned Behaviour

The COVID-19 pandemic and the consequent lockdowns also played a significant role in shaping the methodological choices in exploring the consumer perspective for blockchain applications in SCM and answering the second research question of this PhD. Since literature around consumer perceptions and preferences on blockchain applications in SCM is absent, the initial planning for this stage included an interactive workshop that would investigate how consumers understand blockchain technology, how they perceive its characteristics for supply chain traceability and explore their views on applications for tracking coffee production.

This workshop was based on an interactive and dynamic activity called BlockExchange, designed by the Centre of Design Informatics at the University of Edinburgh and which was adjusted in order to align with the needs of my research. It involved a series of interactive activities in which participants would explore how blockchain works, with a particular focus on the decentralised and collaborative characteristics of the technology, and specifically examine potential SCM applications around traceability and transparency. It finally included a brief questionnaire to evaluate the entire process. The reasoning behind choosing such a methodology, apart from being an established practice in exploring and understanding complex processes behind user-technology interactions (Ørngreen & Levinsen, 2017), was to involve participants in the process of designing potential features of these applications.

Unfortunately, the COVID-19 lockdown began days before the first arranged workshop leading to its cancellation. I immediately started searching for alternatives to move the workshop online, but its nature is such that it would be impossible to replicate the interaction between participants in an online environment. One solution was to use online board game simulators to run the workshop, but upon further investigation, that was also abandoned because a) participants needed to buy/download, install and familiarise themselves with the software b) the features of the software might not allow for all activities of the workshop to be implemented and c) all the interactions between participants will be impossible to monitor/record.

Given the uncertainty of conducting face to face research and the necessity for every potential methodological choice to be conducted in an online environment, I decided to conduct an online study aiming to explore consumers' attitudes, views and purchasing intentions regarding blockchain-traceable organic coffee (compared to coffee with conventional traceability certification) and identify the main psychosocial antecedents behind these intentions. I created two fictional organic coffee products, one supported by a blockchain traceability certification system, and one supported by UTZ certification, along with corresponding descriptions explaining each system, while also providing a mock-up of the app for the additional product information the blockchain product provided (Figure 34 and 35 in Chapter 5). The reason for choosing UTZ as the third-party traceability certification, apart from being one of the most holistic standards as discussed in the literature review, lies in the certification's focus on supply chain transparency (Reinecke et al., 2012).

For my conceptual framework, I employed the Theory of Planned Behaviour (TPB) (Ajzen, 1991), one of the most utilised and discussed theoretical models for predicting intentions and behaviours (Hoppe et al., 2013). The TPB suggests that three main components, namely, attitudes (favourable or unfavourable evaluations of the behaviour), subjective norms (whether significant others approve or disapprove of the behaviour) and perceived behavioural control (PBC) (the individual's perception of the ease or difficulty to perform the behaviour), shape an individual's behavioural intentions, which in turn determines their behaviour. While the TPB has been successfully used in various contexts in the consumer choice literature (e.g., online shopping behaviour (see Lin, 2007)), research has also established its robustness in the food choice context, especially in determining motivational factors for choosing one product over another (Nardi et al., 2019), as well as in predicting behaviour and consumer intentions towards organic products (Armitage & Conner, 2001), in general, and organic coffee (K. H. Lee et al., 2015), in particular.

Although I explored the idea of using one of the technology adoption frameworks for this study (e.g., Technology Acceptance Model (Davis, 1989); Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003)), I decided that these models will not be optimal for my case since for blockchain applications in SCM end-users/consumers are not asked to use or interact with the technology directly, but instead, they are given reading access to the system via an app and are asked about their preference compared to existing certification systems. In contrast, if cryptocurrencies were involved in the research, considering the use of a technology adoption model would be judicious, as they have been already used in studies looking at digital currencies (Arias-Oliva et al., 2019; Mendoza-Tello et al., 2019).

In an effort to increase the TPB's predictive power in the context of food choice, researchers over the years have contributed significantly with the addition of complementary constructs to the original TPB. Even Ajzen (1991) himself encouraged such exploration, suggesting that:

> "The TPB is, in principle, open to the inclusion of additional predictors if it can be shown that they capture a significant proportion of the variance in intention or behaviour after the theory's current variables have been taken into account" (p.199).

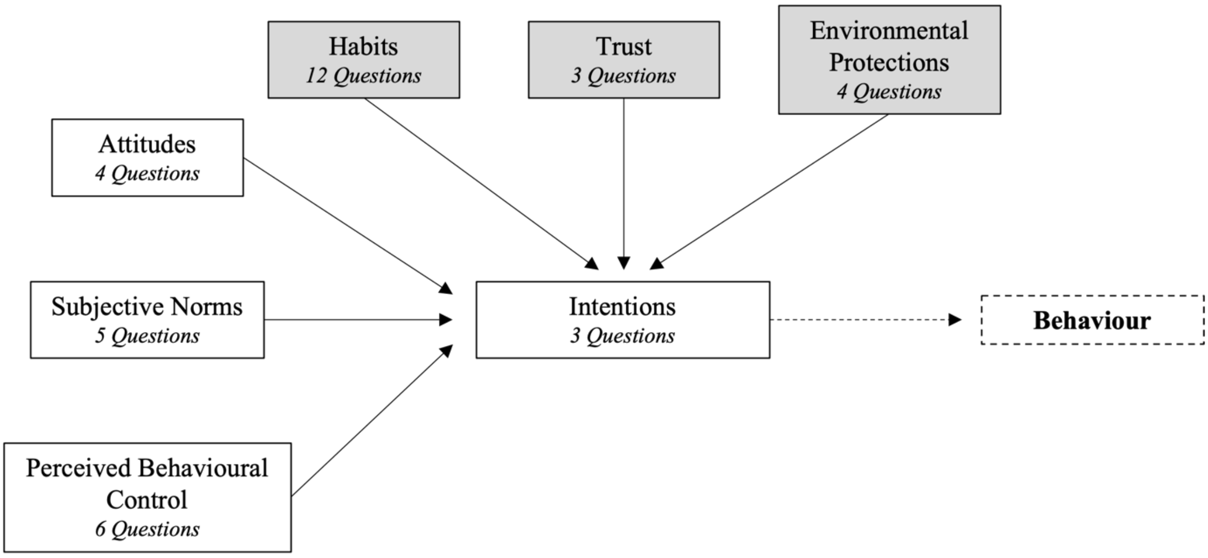
Recent studies suggested that including constructs such as trust and past habits increased the predictive power of the TPB in areas such as traceable chicken and honey (Menozzi et al., 2015), and traceable beef (Spence et al., 2018). In the context of organic coffee, Lee et al. (2015) found that environmental protections were strong contributors to all original components of TPB (i.e., attitudes, subjective norms, PBC), indicating the potential of this variable to directly predict purchasing intentions and increase TPB's predictive power as a standalone construct.

Consequently, this study initially tested the original TPB model by measuring how participant's attitudes towards blockchain traceable organic coffee (compared to UTZ certified organic coffee), perceived social pressure (subjective norms), and their perceived ability to both identify and comprehend origin information and production processes (PBC), influence their purchasing intentions. Next, it assessed an extended TPB model and whether including variables such as participants' past habits, trust, and environmental protections could increase the explained variance (Figure 13). Additionally, and to further explore participants' intentions and attitudes, their behavioural beliefs regarding certain aspects of blockchain traceable coffee as well as their willingness to pay for it, were measured.

My intention for this study was to target average coffee consumers. That is why I was particularly interested in participants that consume coffee at least weekly. Additionally, a series of questions were asked around participant awareness and familiarity of traceability coffee certification along with a few demographic questions. Chapter 5 will further elaborate of the materials used in this study, the proposed hypothesis and discuss its finding.

Figure 13.

Proposed Extended TPB Model Structure



Note. White rectangles represent the latent variables for the original structure of the TPB (Ajzen, 1991), while grey rectangles represent the variables in the extended version (K. H. Lee et al., 2015; Menozzi et al., 2015; Spence et al., 2018). Each rectangle also includes the number of observed variables.

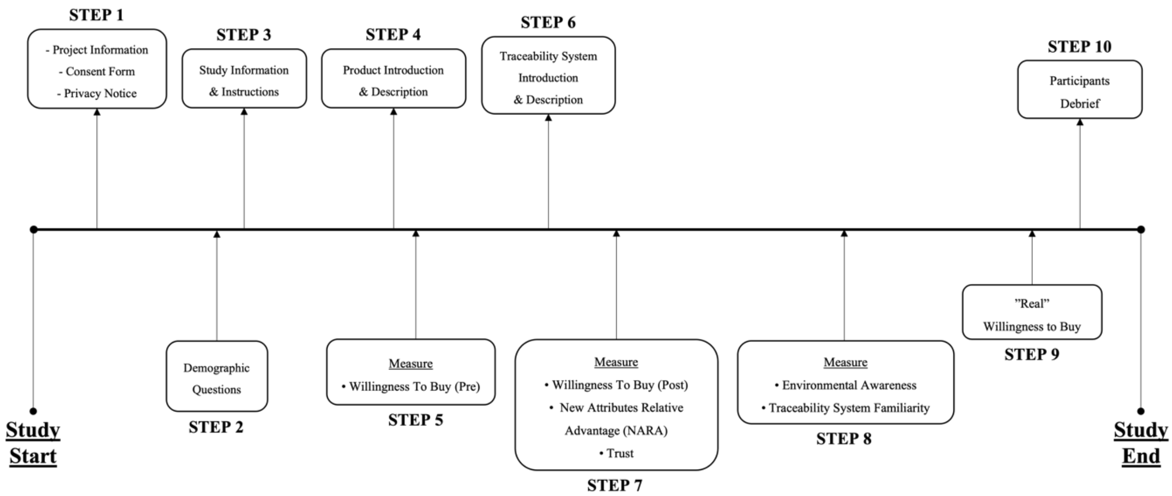
3.4 Study 3: Blockchain Traceability Certification for Organic Coffee - Multiple Labels and Consumer Preferences

The main focus of the previous study was to specifically examine how participants will evaluate the features offered by blockchain technologies for organic coffee traceability. Therefore, the next step in answering this PhD's second research question was to investigate consumer preferences for blockchain certified coffee compared to several other traceability certifications in the market and explore how they evaluate each system's features.

To achieve that aim, the third study in this PhD utilised an experimental design in an online setting. Figure 14 provides an overview of the design used. After reading the project information and providing their consent (Step1), participants were given brief but detailed instructions about the study (Step 2). In contrast to the previous work, whose purpose of exploring blockchain as a traceability certification tool for organic coffee was clear to participants, for this study, I chose to create a setting where participants were informed that a newly formed company was releasing a new organic coffee product and was conducting market research to explore consumer's views and preferences for it. The reason for adopting such an approach was to create a more realistic and "natural" market setting in order to gain consumers' actual views and minimise response bias. It is also important to mention at this stage that this methodological choice links back to the COVID-19 pandemic and the inability to conduct face-to-face research since my initial plan for exploring consumer preference for different coffee traceability certifications involved field data collection in real-world settings (e.g., markets) and/or bringing participants in the lab.

Figure 14.

Experiment Workflow and Timeline



After providing some demographic information (Step 3), participants were introduced to the product (Step 4). They were first presented with the organic coffee but without any traceability certification/system indicators. Apart from describing its key attributes, the accompanying description they received was explicit about the product's green/ethical characteristics, its quality, responsible and ethical sourcing practices, and origin. They were then asked to indicate their willingness to buy (WTB) this product (Step 5).

Participants were then randomly assigned into five different groups, each presented with a different traceability certification that accompanied the organic coffee (Step 6). Table 4 includes the different certifications used and what each condition entails. I aimed for a balance between the various traceability certification approaches discussed earlier and, hence, the study includes traceability based on a company initiative, a third-party scheme, a blockchain platform and a combination of the two latter settings, as well as a variety of visual aids on the product and the provision of additional product information, some of them based on materials used in the previous study (Figures 36 - 39 in Chapter 6). After being exposed to the traceability system, participants were asked to restate their WTB and answer a series of questions regarding trust, how they evaluate the certification features, as well as questions regarding their environmental awareness (Step 7-8).

Table 4.

Experimental Conditions and Descriptions

	Traceability	**Visual Aid on Product**	**Additional Traceability Information**
Condition A	Company Initiative	Initiative Logo Designed by the Company	No
Condition B	Third-Party Certification	Official Third-Party Logo	No
Condition C	Third-Party Certification	Official Third-Party Logo & Interactive Barcode	Yes
Condition D	Blockchain Platform	Interactive QR Code	Yes
Condition E	Blockchain Platform & Third-Party Certification	Interactive QR Code & Official Third-Party Logo	Yes

Since the study measures WTB (i.e., intentions) and in an attempt to explore the possible effect of the intention-behaviour gap (Carrington et al., 2014), a deception mechanism was deployed in which participants were told that the company releasing the product is taking pre-orders, and they can place their own right away. They were then asked whether they would like to pre-order the product. This question was fictional and there was no pre-order option if they answered yes (Step 9). At this stage, the study was completed, and participants were debriefed. The real purpose of the study was revealed, as well the true nature of the pre-order question, and they were given the opportunity to withdraw their participation if they so wished. As with all studies in my PhD, ethical approval was obtained before commencing with data collection (all research ethics approval confirmations from the Nottingham University Business School Ethics Committee can be found in each study's corresponding Appendix).

Redesigning my research because of the impact of the COVID-19 pandemic placed certain time restrictions on my work. Hence participant recruitment for this study took place using

Amazon Mechanical Turk (MTurk) to allow for timely data collection. Using MTurk as a research recruitment tool is a well-established practice (Bartneck et al., 2015) and the additional use of specific parameters for participation (e.g., 95% user approval rating; more than 1000 tasks successfully performed on the platform) also ensured the quality of collected data. Chapter 6 will further expand on the processes involved in this study along with the hypothesis developed and the results of the online experiment.

3.5 Conclusions

The main goals of this chapter were to explain the reasoning process behind formulating the research questions this PhD aimed to address and provide an overview of the methodological choices made for each of the three studies developed to achieve that aim. The duality of my overall research approach was initially discussed, followed by an outline of the methods and models used to both investigate the industry perspective on blockchain application in SCM as well as examine the case of coffee traceability certification and consumer preference for it.

Inevitably, the pandemic's impact on my research was also deliberated, mainly to highlight the direct effects the continuous lockdowns had on the ability to conduct my work and the rapid speed with which I, along with many other colleagues, had to adjust and decide new ways of continuing our work without sacrificing its reliability, focus and overall quality. It is important to highlight that the disruption caused by the COVID-19 pandemic also created two main opportunities, which, in hindsight, allowed me to experiment and expand as a researcher while also significantly contributing to my work's academic robustness.

The first was around the use of online tools for designing and structuring surveys and questionnaires, as well as for data distribution and collection (e.g., Qualtrics, Jisc, MTurk). Although I had used similar software in the past, having to conduct all of my PhD research online contributed to becoming much more comfortable with the inner workings of a wide variety of different survey tools as well as being able to timely (and within cost) collect the required data, an aspect crucial given the impact of the pandemic on my research timeline. The second concerns the opportunity to use, test, and expand the TPB model in the context of consumer choice. Although the initially planned workshop would have allowed an in-depth exploration of consumer understanding of using blockchain for product traceability purposes, the proposed extended TPB model proved equally valuable, as I will discuss in Chapter 7.

The next chapter will delve deeper into the survey materials used to examine the industry perspective, present its findings, and discuss its implications.

4 Study 1: Blockchain Beyond the Code Console – The Perspective of Industry Professionals on Blockchain Applications for Supply Chain Management

4.1 Introduction

As argued in the literature review, examining areas beyond the technical infrastructure of blockchain might prove critical for a company's decision-making process to implement the technology and its general market adoption in SCM. Indeed, early research on business adoption of other collaborative technologies (e.g., consortium business-to-business e-marketplaces) suggests that other factors such as trust, visibility and transparency, data security and privacy as well as keeping up with everchanging regulations, also need to be satisfactorily addressed for a technology's mainstream adoption (A. White et al., 2007). That is also the case with the successful implementation of ERP systems, which Kähkönen et al. (2015) characterised as a socio-technical challenge since, apart from being costly and having specialised technical prerequisites in their initial development and customisation, they also require tackling the social interactions between various stakeholders.

Despite the plethora of research on the technical features of blockchain for SCM, there is still a lack of empirical data on this technology's "social" aspect. Petersen et al. (2018) surveyed the views of professional and supply chain experts around blockchain applications; however, their work examined the future relevance of the technology, adoption barriers, and the possible effects in established business practices and not how these professionals evaluate specific features of blockchain and their implications. More recently, Fosso Wamba et al. (2020) proposed a model that examines blockchain's influence on supply chain performance by surveying industry professionals in the USA and India. Their model demonstrated that knowledge sharing and peer pressure positively affected blockchain adoption, which in turn had a positive effect on supply chain transparency and performance. However, their work did not examine other aspects of blockchain applications such as trust, collaboration and information sharing regarding production and business practices (rather than sharing knowledge around blockchain in general) as well as regulatory compliance.

These are some of the aspects this study will address while also investigating whether adopting blockchain for a specific business problem is the appropriate decision for industry professionals or whether a more conventional solution is sufficient. Ultimately, the goal of this chapter is not merely to answer the first research question and shed light on this understudied area but to also provide decision-makers with some of the social and collaborative aspects of the technology that they need to consider before embarking on a blockchain project, as well as offer potential "food for thought" for organisations that are currently experiencing stagnation in their blockchain project. As Vadgama & Tasca (2021) concluded in an overview of blockchain adoption in supply chains over the last decade, there is no research to determine the reasons for the success or failure of a blockchain project and any inferences made are based on market statistics and indicators.

In order to make the first step in providing these insights, an online survey among 12 industry professionals working on blockchain applications in SCM was utilised. Since this study is exploratory in nature, no specific directional hypotheses were formed. In the rest of this chapter, I am going to elaborate on the measures used in the survey (4.2) and present its results (4.3), while also discussing its implications (4.4 and 4.5).

4.2 Materials and Methods

4.2.1 Data Collection and Sample Description

A survey was developed and launched using Jisc's online survey tools and was open for participation between February and August 2020. After tracking down and mapping companies and organisations utilising blockchain for SCM applications in the UK and EU, emails were sent inviting them to participate in the study. As mentioned previously, invitations were also sent via my industry partner and to parts of the University's industry network. A link to the survey was also uploaded to various LinkedIn groups. A total of 32 responses were recorded; however, only 12 were in full and suitable for further analysis, representing a total of 11 different companies and organisations.

At the initial stage of the survey, I informed participants about the purposes of the study, its funders and that there were no commercial motives behind it. They were also assured that all data would be fully anonymised and that any materials produced would not identify them in any way. Approval from the Nottingham University Business School Ethics Committee was obtained before data collection. Each participant provided their consent at the beginning of the study and was also offered details on how to withdraw from the research at any point if they so wished.

Table 5 (next page) includes demographic information from the final sample. We can observe that all participants occupy senior positions in their respective organisations, from managerial roles to directors and executives, and their main focus revolved around various aspects of SCM, ranging from software development to supply chain research and data management. In addition, all participants had at least an average know-how around blockchain technologies, while the majority of organisations they work for were small and mid-size enterprises (SMEs), and the sector within which they operate comprised a mix of start-ups as well as commercial and state-owned enterprises.

4.2.2 Survey Measures

After granting their consent and providing their business demographic information, participants were asked to answer a series of questions about the main challenges in their industry and the blockchain-use cases they are working on as well as their views around blockchain consortiums. The next set of questions covered the first element of this research. It included participant attitudes on trust, managing multi-stakeholder relationships, tracking provenance and production and regulatory compliance, while the survey closed with the second main element of this study, the decision-making flowchart. Table 6 includes an overview of the aspects covered in the survey.

Table 6.

Survey Measures Overview

General Blockchain Questions	- Industry Challenges and Blockchain Use-cases (2 Items) - Blockchain Use-Case Metrics (5 Items) - Blockchain Benefits and Adoption (3 Items) - Consortium Stance (3 Items)
1st Element: Attitudes Towards Blockchain Characteristics 7-Point Likert Scale (1: strongly disagree - 7: strongly agree)	- Trust & "Trust-Free" Applications (5 Items) - Tracking Provenance and Production (4 Items) - Managing Contracts and Multi-Stake Holder Relationships (6 Items) - Regulatory Compliance (3 Items)
2nd Element: Flowchart	- Decision-Making Flowchart (6 Items)

Table 5

Participant (P) and Organisation Demographics

#	Participant's Role	Participant's Focus	Blockchain Know-how	Organisation's Size	Organisation's Type	Organisation's Sector
P1	Digital Transformation Manager	Supply Chain Research	Above Average	SME	Commercial Enterprise	Pharmaceutical
P2	Head of Customer Success	Manufacturing & Processing	Above Average	Multinational Enterprise	Commercial Enterprise	Pharmaceutical
P3	Technical Manager	Energy and Natural Resources	Average	Large Enterprise	State-Owned Enterprise	Energy
P4	Enterprise Data Manager	Environmental Remediation	Above Average	Large Enterprise	State-Owned Enterprise	Energy
P5	Logistics Manager	Supply Chain Management and Logistics	Average	Large Enterprise	State-Owned Enterprise	Healthcare
P6	General Manager	Consumer Healthcare	Average	Multinational Enterprise	Commercial Enterprise	Pharmaceutical
P7	Lead Developer	Blockchain Technologies	Excellent	SME	Start-Up	Software Engineering (Logistics)
P8	CEO	Software Development	Average	SME	Start-Up	Software Engineering (Transportation)
P9	Head of Technology	Software Development	Above Average	SME	Start-Up	Software Engineering (Aerospace)
P10	Commercial Lead	Aviation Data Management	Above Average	SME	Start-Up	Software Engineering (Aviation)
P11	Director	Manufacturing and Processing	Above Average	SME	Start-Up	Food Industry
P12	Procurement Specialist	Supply Chain Management and Logistics	Above Average	SME	Commercial Enterprise	Food Industry

Note. The 12 participants in the study represent 11 different organisations

Participants began by stating the industry's main challenges, followed by the specific blockchain use cases they are developing. They then answered a series of questions on their blockchain readiness level, the metrics their organisation is going to use to evaluate their blockchain project progress, their expected timeframe for return on this investment, the future relevance the technology will have for them and any regulatory concerns they might have regarding their blockchain implementation. A set of more general questions about blockchain was also asked, including the advantages of the technology compared to existing systems and the barriers to greater adoption. Finally, participants were also asked to provide their views on blockchain consortiums, including join criteria, expected benefits for joining, and their current status on participating in one.

Next, I explored participants' views and attitudes on four main blockchain characteristics. Five questions measured the level of trust that blockchain applications provide as well as the role it plays in their business interactions in general. Tracking provenance and production were assessed using four questions which again probed both blockchain's capacity to enhance supply chain traceability and its broader importance for their business. The ability of blockchain to strengthen multi-stakeholder relationship management was measured using six questions which enquired about the significance of information and data sharing between their business network and beyond and how blockchain can facilitate it. Finally, aspects of blockchain regulatory compliance and its significance in SCM were evaluated using three questions.

This survey's second and final element presented participants with the modified decision-making flowchart (Figure 11). Before proceeding, they were given the following instructions: "*Having in mind a business problem or a specific application that your company/organisation is considering applying a Blockchain solution to, please answer the following questions with a YES or NO answer*." Participants were then asked to answer a series of questions that, depending on their answers, would prescribe which blockchain type they might need (Permissionless, Public Permissioned, Private Permissioned) or if they need one at all (No Blockchain). The process started by asking them whether they need to store data, if multiple people need to access the database, the existence of a trusted third party to verify transactions, whether all network participants are known and trusted and whether it is necessary for the information in the database to be publicly verified. At the end of the flowchart, participants received a short description of their suggested systems and were thanked for their time.

4.2.3 Data Analysis

As mentioned in the introduction, this study is exploratory in nature, and no specific hypotheses were developed and tested. Therefore, a series of descriptive statistics were employed to analyse the data using IBM Statistics for macOS, Version 27.0.

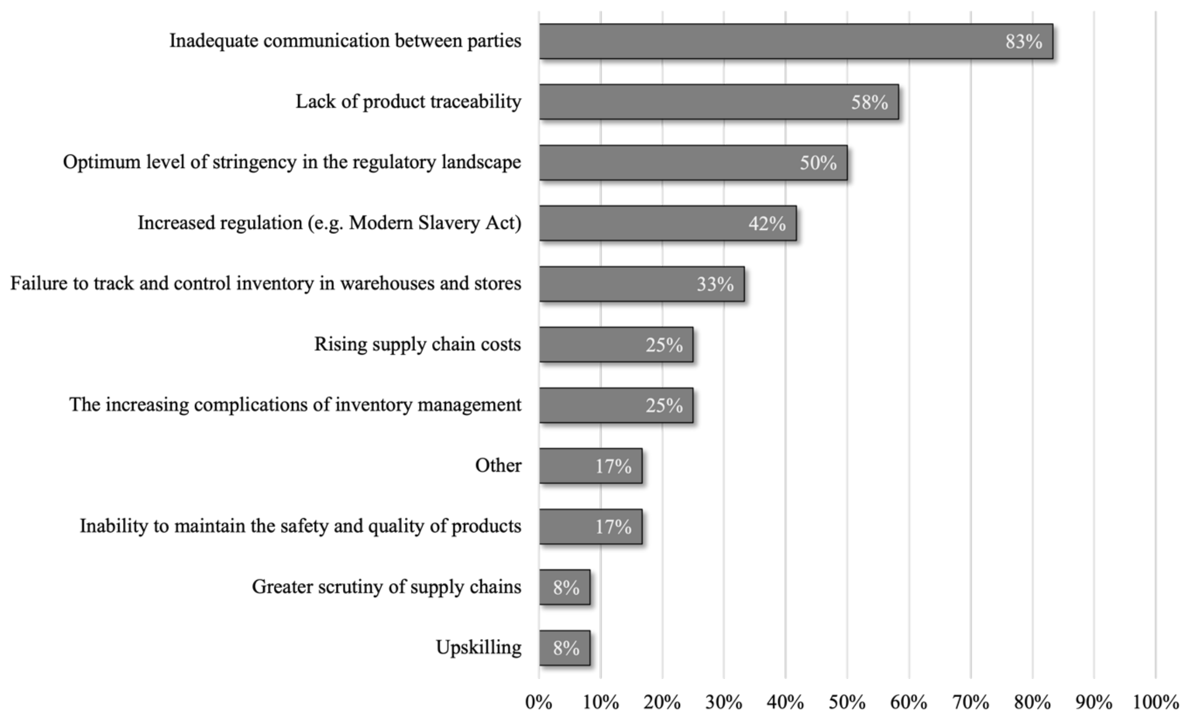
4.3 Findings

4.3.1 General Blockchain Questions

Figure 15 illustrates participants' responses regarding the main challenges their industry is currently facing. Inadequate communications between different parties emerged at the top of the list, while the lack of product traceability followed in second place. Increased regulation and stringency were next in the challenges participants reported, with aspects of inventory management and supply chain costs occupying a smaller part of their responses. Finally, aspects like product safety, supply chain scrutiny and upskilling only attracted limited attention from participants.

Figure 15.

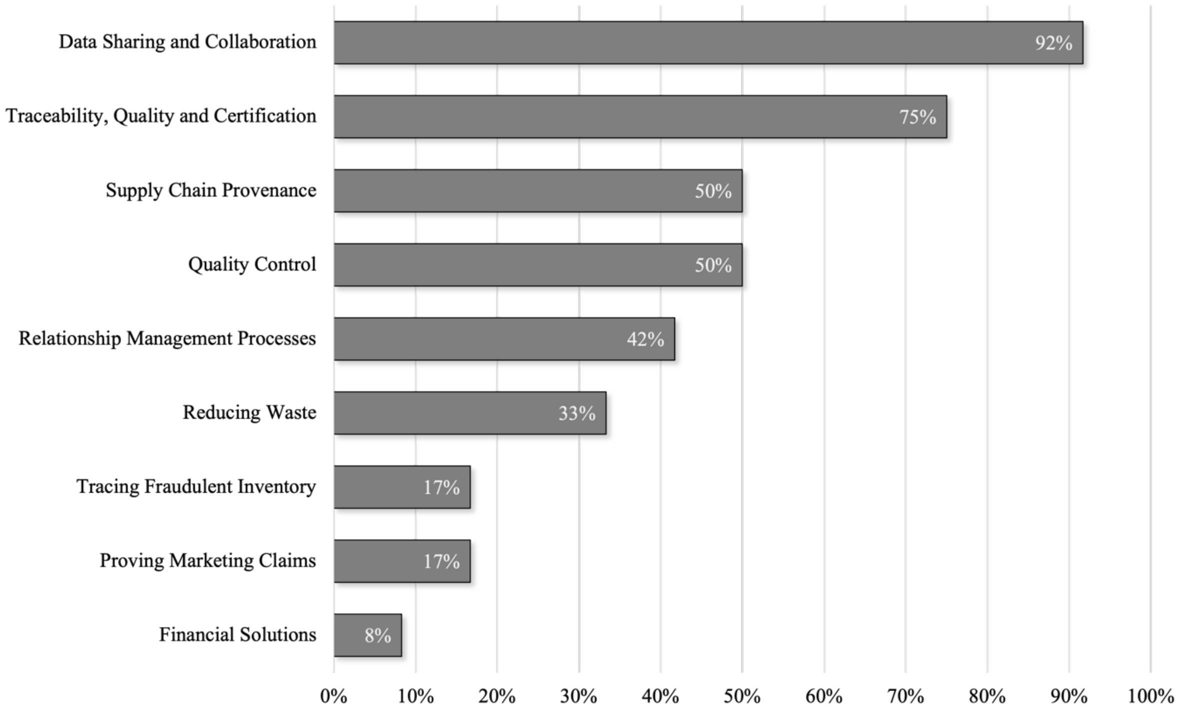
Question: What are the top challenges your industry is facing today?



The blockchain use cases participants are considering/developing also align with the challenges reported, with Figure 16 further illustrating this point. Data sharing and collaboration were selected from all but one participant while use cases around traceability, quality, and certification by three-quarters of the sample. Supply chain provenance and quality control are also applications that half of the participants consider, while managing relationships and reducing waste attracted less attention. Fraudulent inventory, marketing claims and finance were the least selected application. At the same time, more than half of blockchain projects are in research or development stages, with 25% being ready to demonstrate and only one being used by customers/end consumers (Figure 17).

Figure 16.

Question: What use cases is your company/organisation considering (or implementing) for blockchain?



Regarding the metrics participants are using to measure business case results in their blockchain project, we can see in Figure 18 that time and cost-saving, as well as risk reduction, emerged as the top choices for three-quarters of participants, with process efficiency closely following. Around half of the participants reported that enabling new business models and customer acquisition will be important metrics, while revenue generation emerged as the least relevant one.

Figure 17.

Question: What is the level of your company's/organisation's readiness for blockchain?

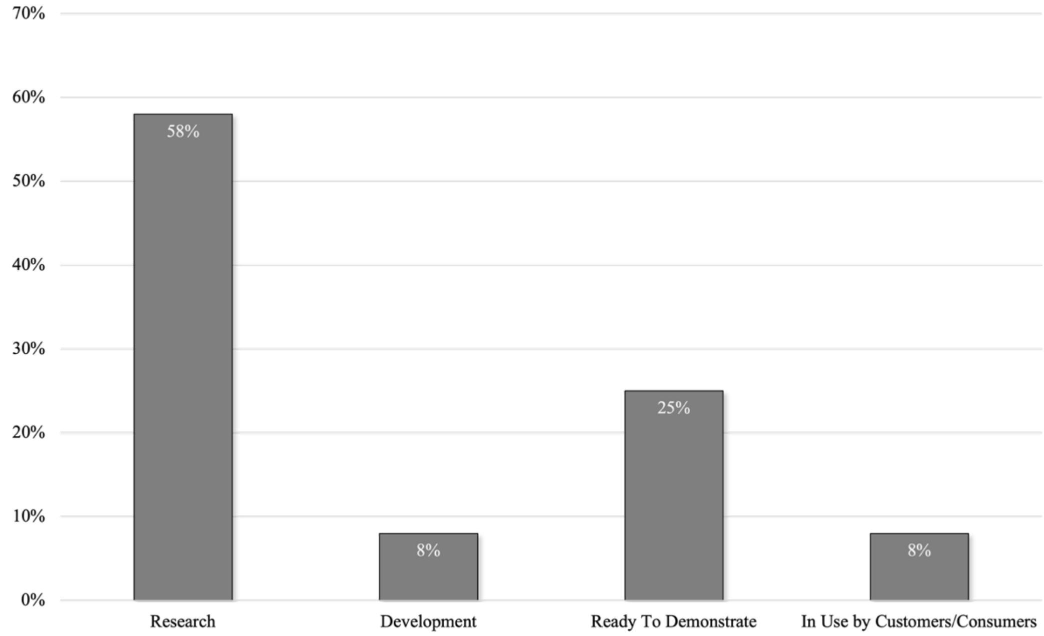
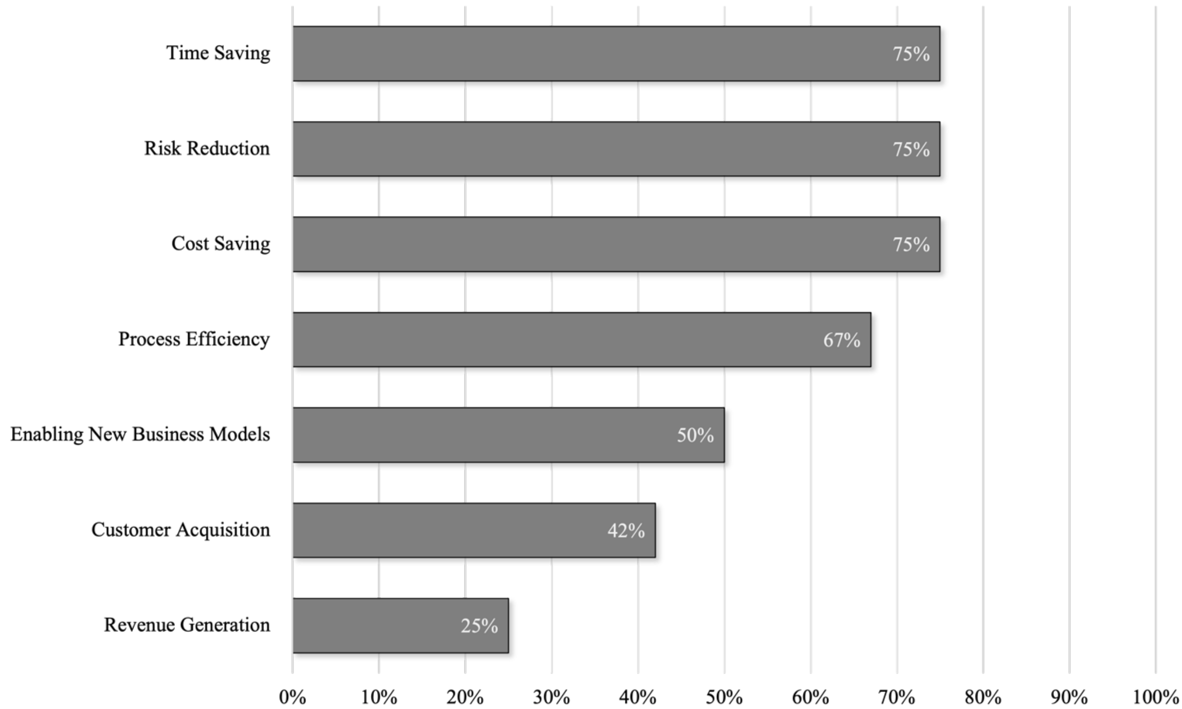


Figure 18.

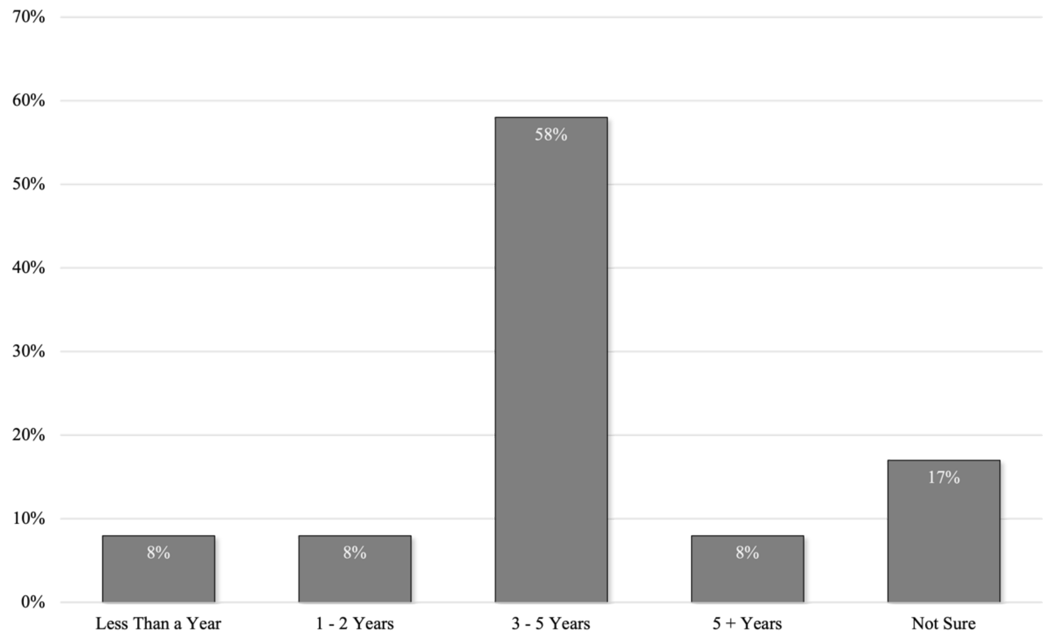
Question: Which of the following metrics is of importance to your company in order to measure blockchain business case results?



Participants' responses to their organisation's expected time frame of achieving a measurable return on their blockchain investment (ROI) are depicted in Figure 19. More than half of the sample reported a time frame of 3-5 years, while almost a fifth could not provide a certain answer. However, a more confident set of answers emerged from the question of blockchain's future relevance for their organisation, with 67% reporting that the technology is a strategic priority for their company, of which 25% include it in their top three priorities (Figure 20).

Figure 19.

Question: What is the expected timeframe to achieve measurable/verifiable return on your blockchain investment?

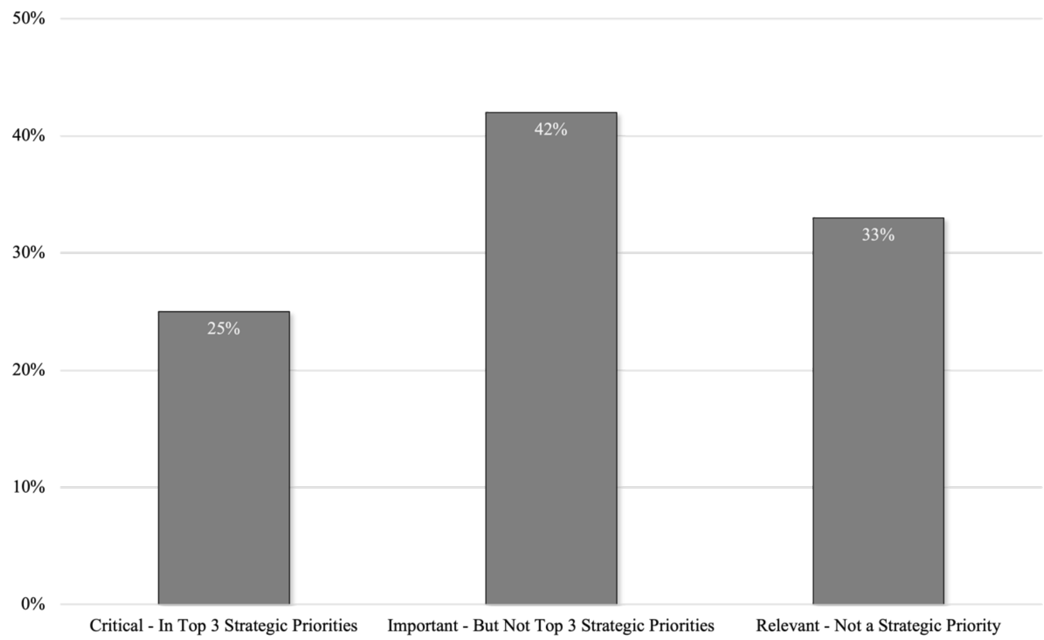


Privacy emerged as the top blockchain-related regulatory concern for almost all participants, with industry-specific regulation and information reporting coming second and third, respectively (Figure 21). Less than half of the participants also reported concerns about geography-specific regulations and payment integration, while regulatory topics around smart contract enforceability, taxation and money transmission were not aspects of significant consideration.

When asked about the advantages of blockchain technologies for their company compared to other solutions, the lion's share of participants reported the potential for greater transparency as the leading advantage, with greater security and lower risk coming a close second (Figure 22). Half of the participants also consider that bettering identity control, improved speed (over existing systems) and the potential for new business and value model creation are important facets of the technology, with tackling fraud and reducing costs drawing less attention. Additionally, three-quarters believed that blockchain is more secure than existing systems, while only one suggested it is less secure (Figure 23).

Figure 20.

Question: Which of the following best reflects your current view of the relevance of blockchain to your company/organisation in the coming years?



Another interesting finding concerns participants' responses to the barriers to broader blockchain adoption (Figure 24) in the foreseeable future. The lack of trust amongst network participants and the current regulatory uncertainty were the leading responses, while the technology's interoperability and potential users' inability to see clear benefits closely followed. Less than half of participants mentioned audit/compliance concerns and the technology's instability, while cost and inability to scale were even less concerning for them.

The final section of the general blockchain questions covers participants' attitudes around the idea of participating in blockchain consortia. Figure 25 illustrates the main criteria for joining such an initiative, with participants clearly stating that the alignment of objectives is the most important reason while having an established governance framework and robust policies, as well as the affordability of participation, were mentioned by more than half of participants.

Figure 21.

Question: What blockchain related regulatory issues are of concern to your company?

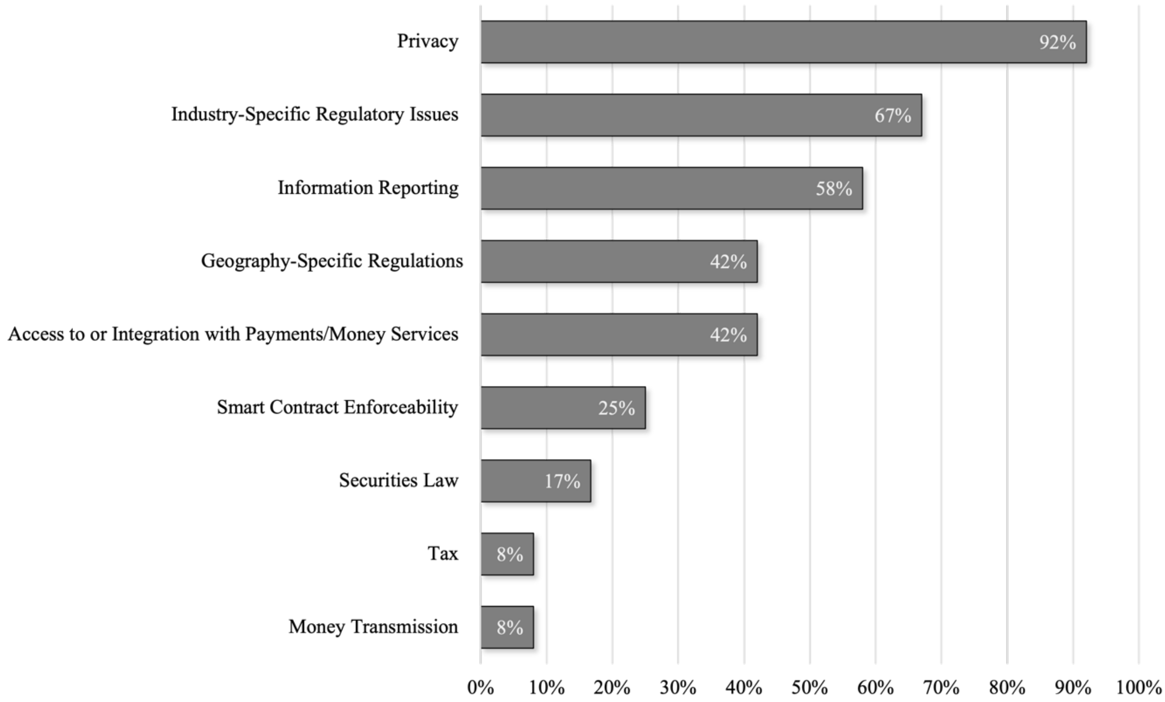


Figure 22.

Question: Which of the following is the most significant advantage of blockchain over existing systems when thinking of your specific industry?

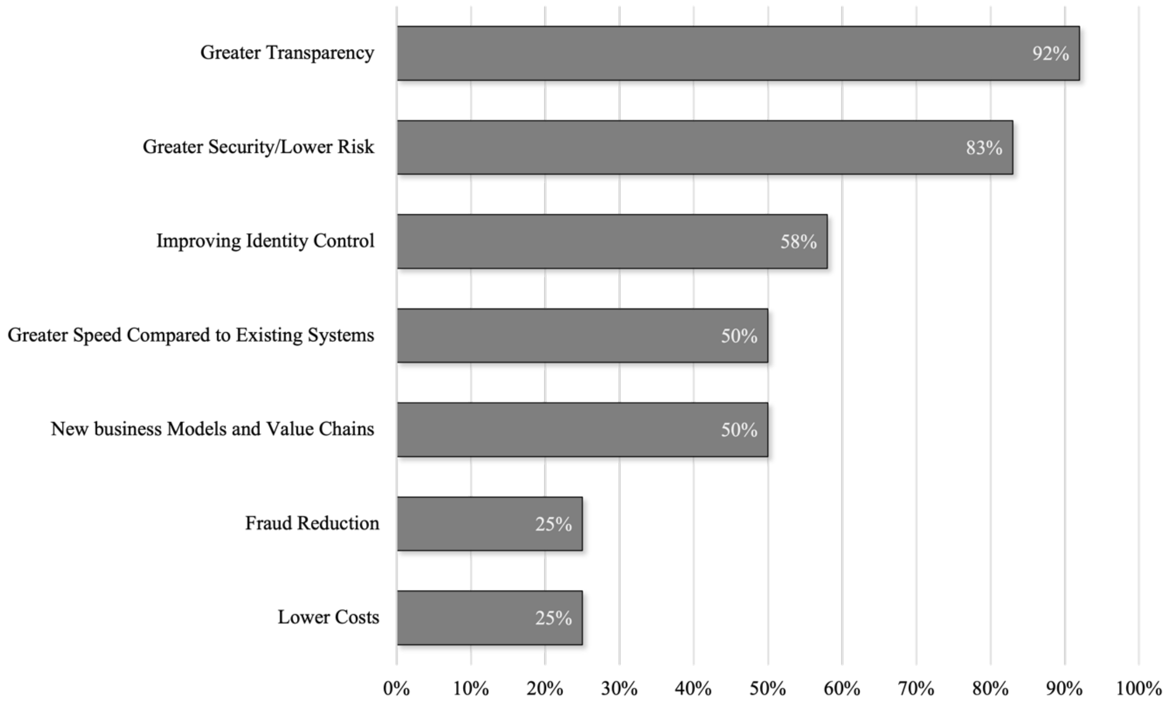


Figure 23.

Question: What do you believe is the level of security blockchain-based solutions offer compared to conventional IT systems?

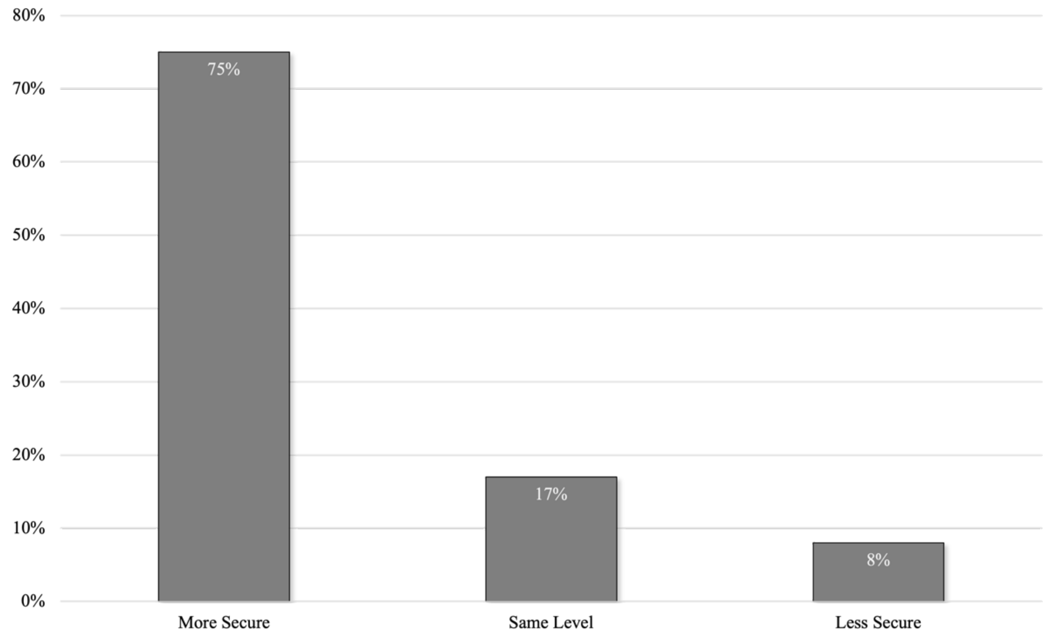
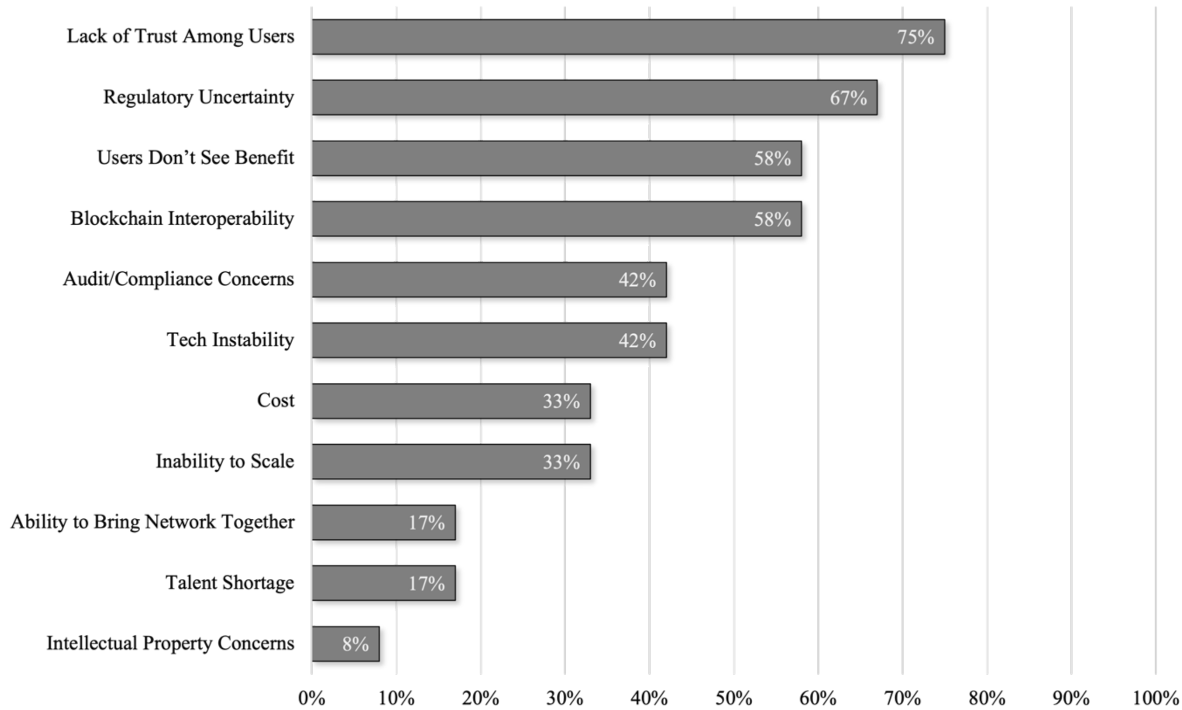


Figure 24.

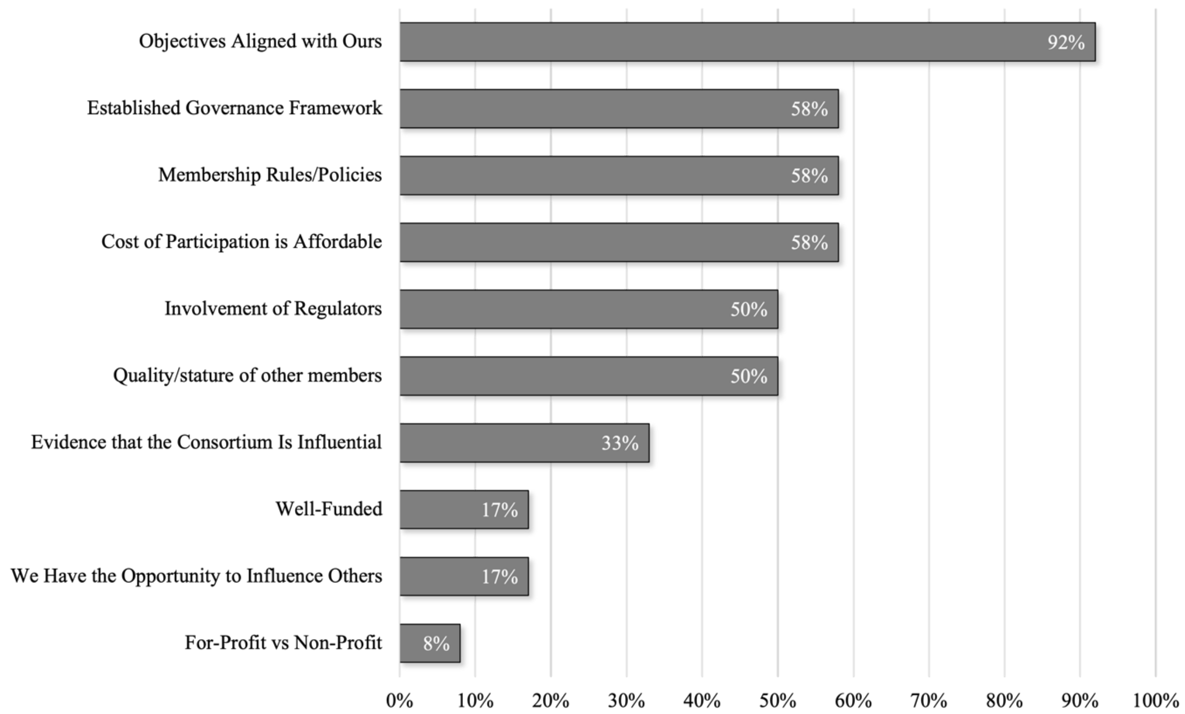
Question: Which of the following will be the biggest barriers to blockchain adoption over the next 3-5 years?



Aspects around the involvement of regulators and the reputation of other members also attracted a fair number of responses, while funding and authority did not play a significant role in the decision to participate in a consortium.

Figure 25.

Question: If your company was given the choice to join a consortium/network, which of the following criteria you would use to choose one vs the other?



Regarding the benefits participants expect to gain from joining a consortium (Figure 26), more than half reported that influencing standards and accelerating learning will provide the most value while building adoption momentum in the market and maintaining relevance followed next in the list. On the other hand, aspects of risk-sharing and cost-saving were perceived as the least beneficial of joining a consortium.

Finally, when asked about their current status around consortiums, 42% reported that they are currently involved in one, of which 25% as leaders, 17% are considering joining while 33% are not planning to join one (Figure 27).

Figure 26.

Question: What benefits would your company expect to get from joining a consortium?

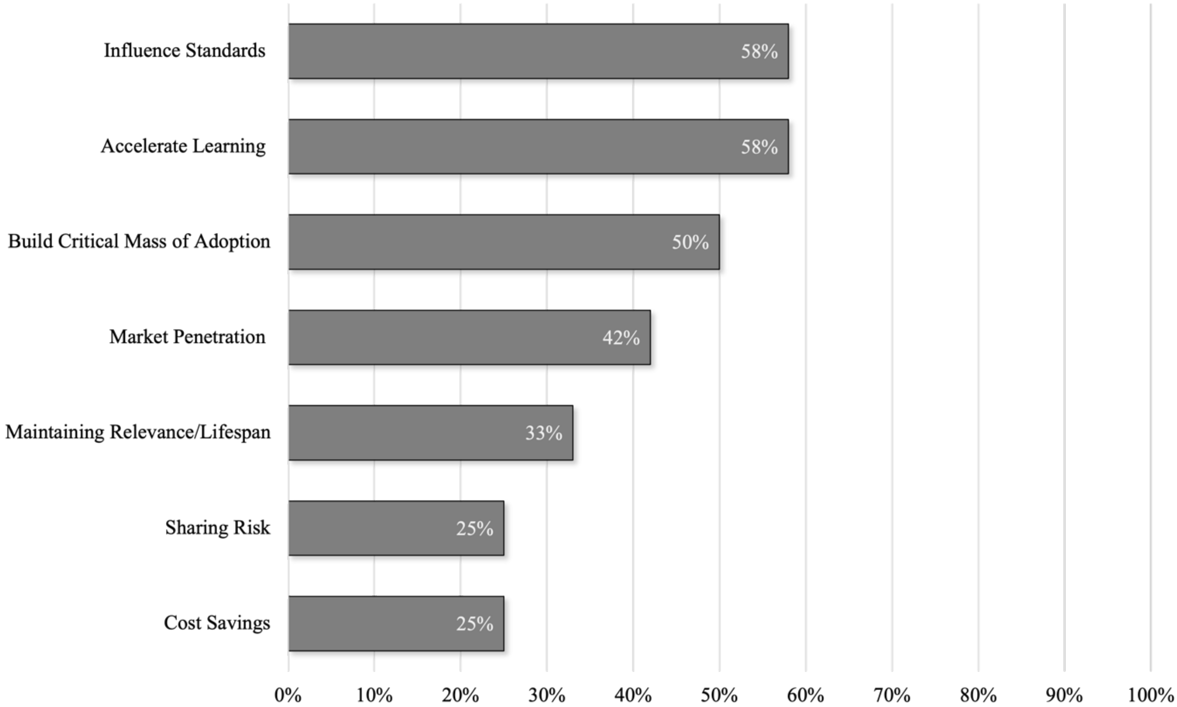
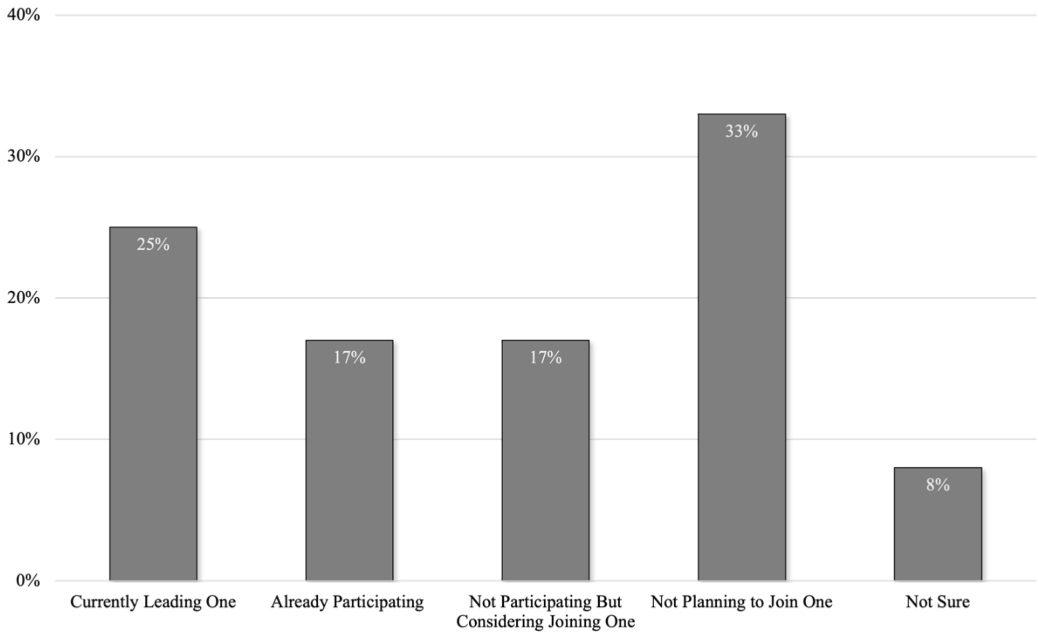


Figure 27.

Question: Which of the following statements best aligns with your company's position on participating in a consortium with competitors?

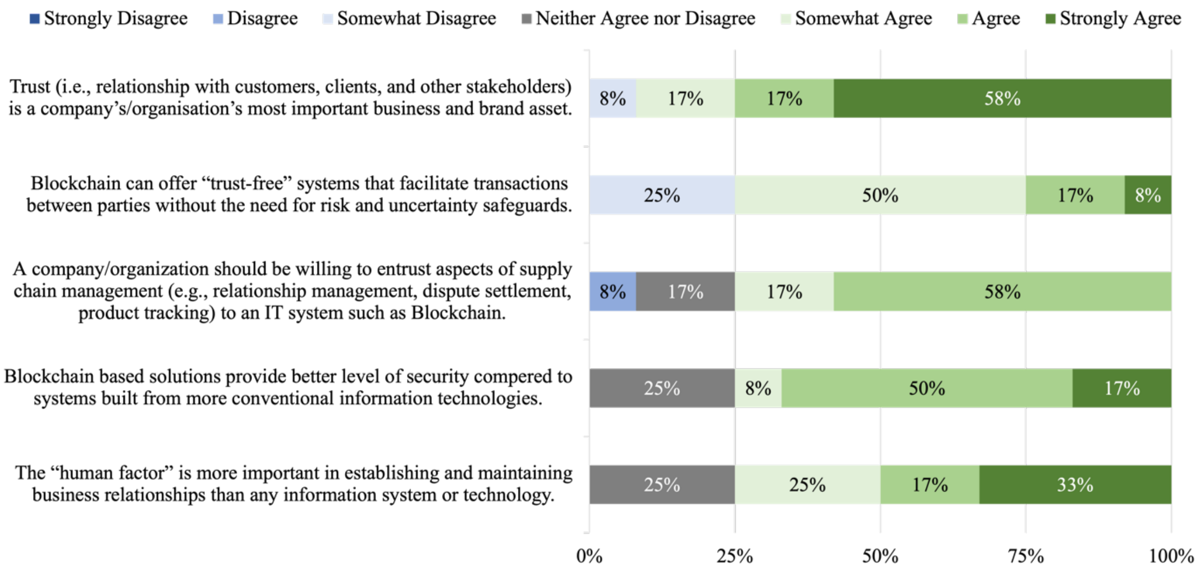


4.3.2 Attitudes Towards Blockchain Characteristics

Figure 28 includes participants' responses regarding trust and the notion of "trust-free" applications blockchain introduces. We can observe an overall positive attitude across all questions. Participants agreed overall that trust is a fundamental factor in their business, while there was also favourable agreement regarding blockchain's ability to reduce transaction risk. Blockchain's ability to facilitate reliable and secure transactions was also viewed favourably by participants, although most agreed that the "human factor" still plays a significant role in business relationships.

Figure 28.

Trust and "Trust-Free" Applications



Participants also exuded positive attitudes when asked about their views on the role of blockchain in supply chain traceability and provenance (Figure 29). The majority supported the importance of meticulous traceability mechanisms to track production, while there was total agreement on blockchain's ability to provide such systems. Not all participants agreed on the importance of digital representation of physical assets in supply chains while providing partial access to the system so that end customers/consumers can reliably verify product provenance was favourably viewed.

Managing business relationships and contracts was also viewed positively by participants (Figure 30). The majority agreed on the importance of robust business and network relationships in supply chain efficiency, while the same level of agreement is observed on the benefits of information sharing between business parties and providing blockchain access to suppliers to optimise business processes. Participants did express some concern regarding the types of data that will be stored in a blockchain system. However, they all agreed that smart contracts could be a reliable way of facilitating business transactions. Interestingly, although most disagreed that providing blockchain access to their network would jeopardise business practices, almost half of the participants expressed some ambiguity about that statement.

Figure 29.

Tracking Provenance and Production

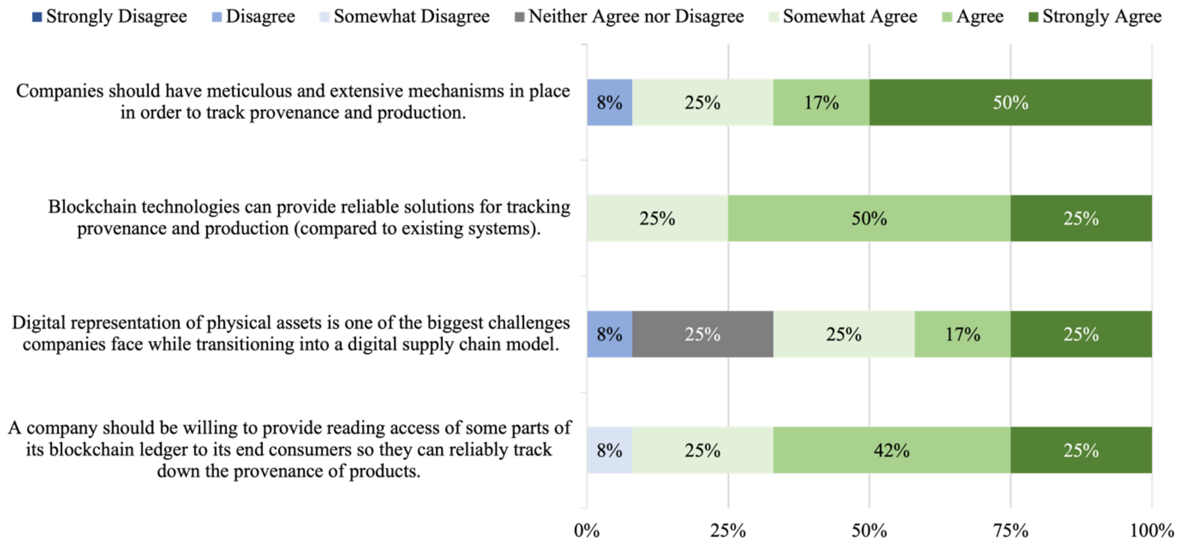
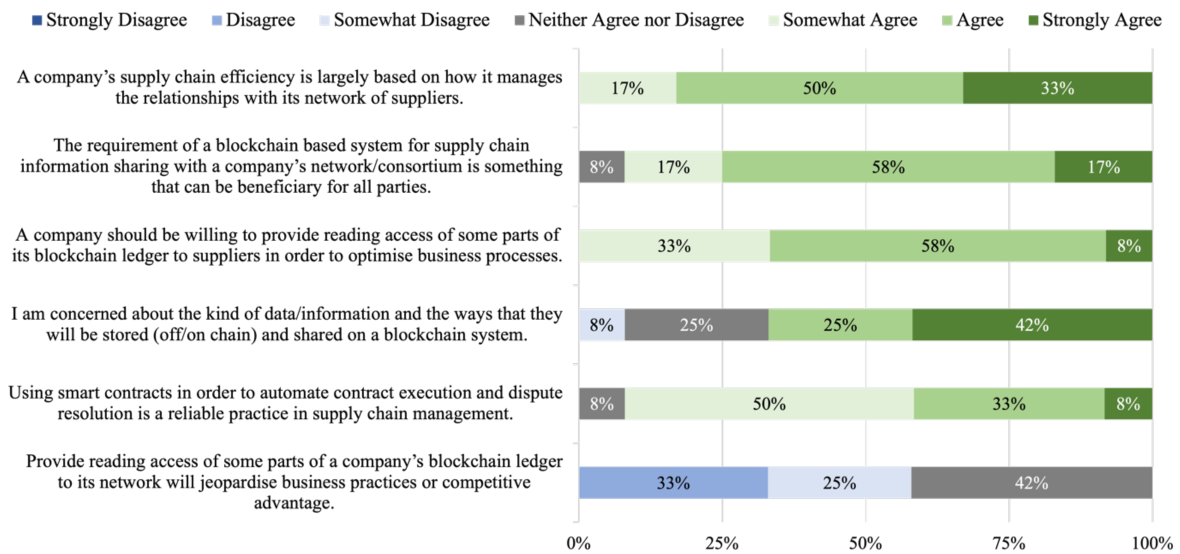


Figure 30.

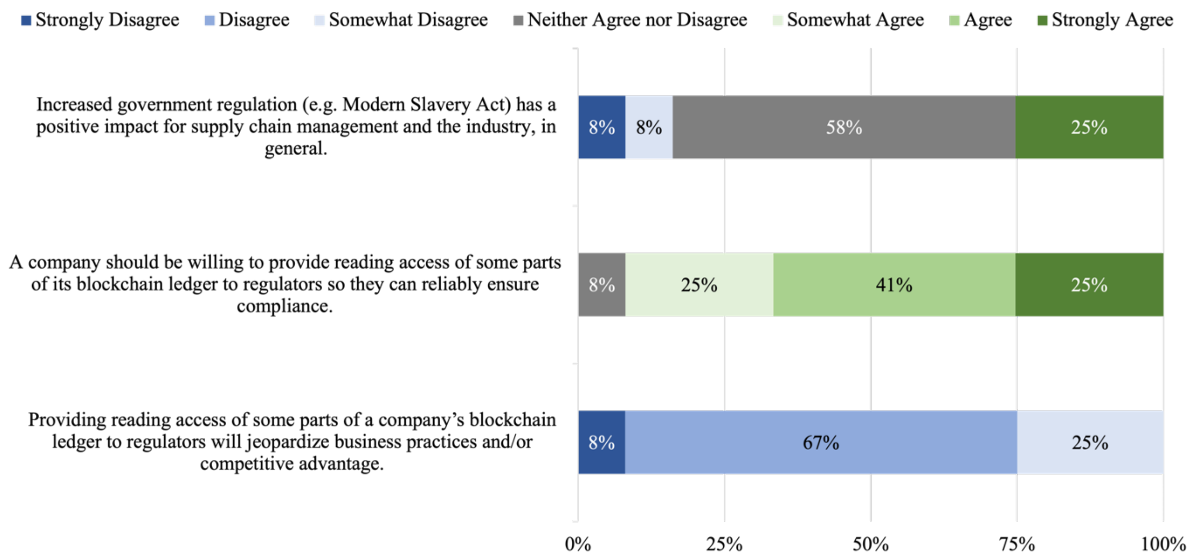
Managing Contracts and Multi-Stake Holder Relationships



Finally, when asked about regulatory compliance matters, only a quarter of participants agreed that increased government regulation positively impacts their supply chain, with the majority expressing a neutral view. However, granting regulators access to a company's blockchain for compliance purposes was viewed favourably by participants, while there was unanimous agreement that such access will not jeopardise business practices and/or competitive advantage (Figure 31).

Figure 31.

Regulatory Compliance

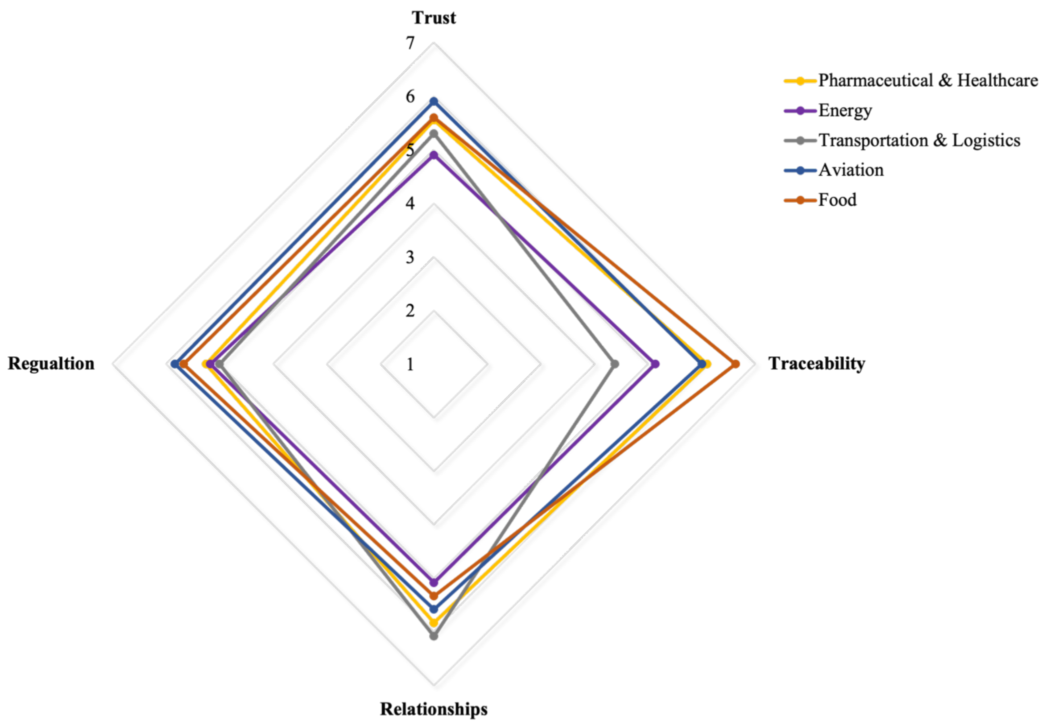


The concluding step in this part of the analysis involved exploring participants' views on these four blockchain aspects based on the sector within which they operate. Participants from the pharmaceutical and health sector were merged, as did those from the logistics and transportation as well as the aviation and aerospace industries, to create the five categories (Figure 32). Scores for each blockchain aspect were averaged, with the last statement of both the managing contracts and multi-stakeholder relationships and regulatory compliance aspects being reversed scored to correspond with the rest of the statements.

Although there is an overall positive attitude towards all four blockchain aspects, Figure 32 reveals some variations between participants from the different sample-specific industries. For example, although participants from all industries revealed positive views towards the trust aspect, with the ones from aviation coming on top by a close margin, energy industry professionals were more neutral. The same pattern can be seen in the traceability aspect, with food sector participants clearly having the most positive views while the logistics sector had a more cautious stance. Managing multi-stakeholder relationships also attracted positive views across the board, with participants from the logistics industry coming on top while companies from the energy sector were less favourable. Finally, professionals from the aviation industry viewed the regulatory aspect of blockchain most favourably, while the ones from logistics recorded the lowest score.

Figure 32.

Participants' Sector Averages for Blockchain Aspects



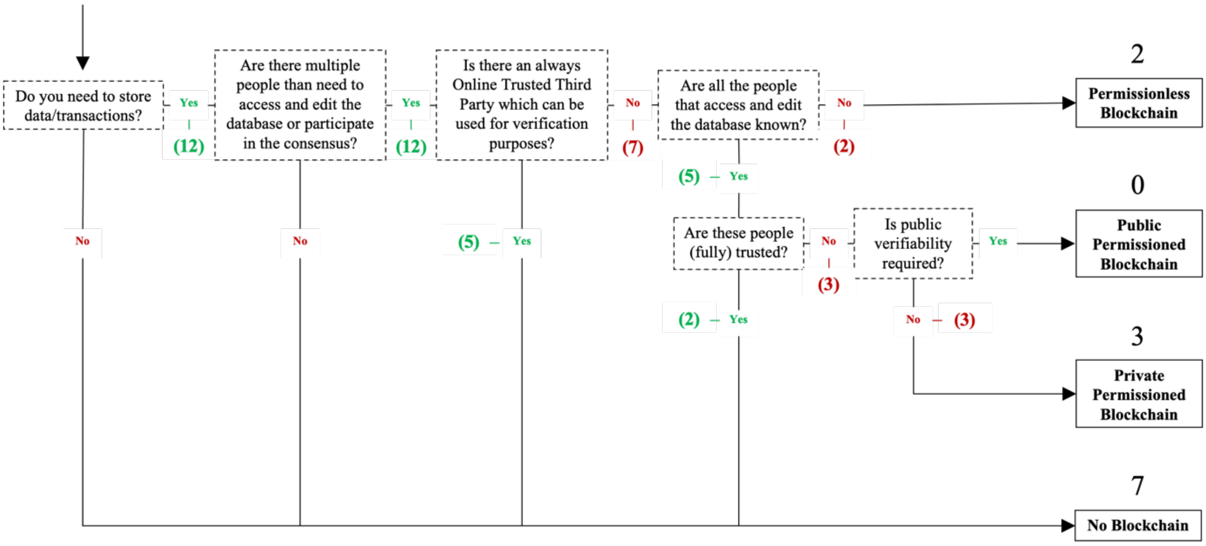
Note. Scored on a 7-point likert scale (1: strongly disagree - 7: strongly agree).

4.3.3 Decision Making Flowchart

The final part of this study includes the results from the decision-making flowchart (adopted from Wüst & Gervais (2018)). Figure 33 illustrates the participant's decision-making process and the outcome. All participants needed to store data/information for their business case, and all agreed that multiple actors needed to access it. However, seven indicated the absence of an always-online trusted third party for verification purposes, of which two suggested that not all people that participate in the network are known, and hence, a permissionless blockchain solution was proposed. Of the remaining five, three suggested that not everyone in the network

Figure 33.

Decision Making Flowchart



Note. Numbers in parathesis indicate how many participants moved to each section of the flowchart, while numbers on the right side indicate the totals for each outcome.

is trusted but that public verifiability is unnecessary, leading to the private permissioned blockchain suggestion. Table 7 includes the recommended outcomes for each responder based on their sector. For just above 40% of the sample, a type of blockchain was suggested as a potential solution to their business problem. Interestingly, there was a proposed blockchain system for each of the five participant industries in the study.

Table 7.

Individual Flowchart Outcomes Based on Participant's Sector

#	Sector	Outcome
P1	Pharmaceutical & Healthcare	Private Permissioned Blockchain
P2	Pharmaceutical & Healthcare	No Blockchain
P3	Energy	Permissionless Blockchain
P4	Energy	No Blockchain
P5	Pharmaceutical & Healthcare	No Blockchain
P6	Pharmaceutical & Healthcare	No Blockchain
P7	Transportation & Logistics	No Blockchain
P8	Transportation & Logistics	Private Permissioned Blockchain
P9	Aviation	Permissionless Blockchain
P10	Aviation	No Blockchain
P11	Food	No Blockchain
P12	Food	Private Permissioned Blockchain

4.4. Discussion

Several academics and industry commentators alike (Alabdulwahhab, 2018; Dey et al., 2022; Harding, 2021; Ragnedda & Destefanis, 2020) have suggested that the emergence of blockchain and distributed ledger technologies marks the transition towards Web 3.0, denoting the changeover from the current state of the internet (Web 2.0), dominated by, what turned out to be, a highly centralised platform economy (Voshmgir, 2020), to a more decentralised, trustless, automated, and ubiquitous state. This increased growth and development of web-based commerce over the past decade (Porter & Heppelmann, 2014), combined with the ever-expanding operational complexity of modern supply chains discussed earlier, have created the need for more advanced systems and protocols that can facilitate commercial activity in a more efficient and reliable way.

Although blockchain is, in the eyes of many, an appealing proposition, poised to facilitate this challenge, it was demonstrated earlier how the current state of the market finds itself in a growth and adoption gridlock. This stagnation is further prolonged by the lack of research that goes beyond the technical development of these systems and examines the industry's attitudes and evaluations of blockchain features and whether it's the appropriate solution for their supply chain. This study aims to shed light on this research area and answer this PhD's first research question.

The study revealed an overall positive attitude toward blockchain technology and its main characteristics. Participants believed the technology to be more transparent and secure than existing systems, with data sharing and collaboration, traceability, quality certification, and supply chain provenance being the primary use cases explored. Most of the sample is in the research stage of their project, with an expected 3-5-year window for return on their investment and viewed blockchain as an important future priority. Participants expressed regulatory concerns around privacy and information reporting, which, along with lack of trust among network participants and interoperability, were cited as the most significant barriers to the technology's adoption. Participation in blockchain consortia was also regarded positively, particularly in accelerating learning and building adoption momentum, with more than half of the sample participating or contemplating joining one. Finally, the decision-making flowchart suggested that for 40% of participants, blockchain would be an appropriate solution for their business use case.

The findings around participant's general blockchain views are in line with previous research that has examined both the opinions of professionals as well as other data sources. Unsurprisingly, the Capgemini industry survey (Pai et al., 2018) also suggested that the lack of traceability, the risks involved with managing multiple business networks, and the level of regulatory compliance are the main challenges modern supply chains face and potentially drive blockchain exploration and experimentation. However, participants in this study reported a 30% higher readiness level for their applications, which is more in line with recent work (Vadgama & Tasca, 2021), suggesting a certain degree of progress over the past years. The blockchain use-cases around information sharing, traceability, and overall supply chain transparency also aligns with findings in the literature (Blossey et al., 2019; Pai et al., 2018), while the same was true regarding the significant future relevance of the technology expressed in this study, with Petersen et al. (2018) reporting a similar strong belief in industry professionals that blockchain will be greatly impactful for SCM and their business moving forward.

Participants also expressed overall positive attitudes around the four blockchain characteristics examined in the study. Newly published research (Friedman & Ormiston, 2022) that examined blockchain as a driver for sustainability in global food supply chains by interviewing industry professionals further enhances this finding and suggests that blockchain was not simply viewed as a technical tool but as an opportunity to swift the general philosophy and overall mentality of the industry towards sustainability through the transparency and collaborative features it offers. This notion is supported by this study's findings, with participants not only positively valuing trust and the importance of robust business relationships based on information sharing but also believing in blockchain's ability to facilitate them.

The same sentiment was expressed by participants in Fosso Wamba et al. (2020) study, who believed that broader blockchain adoption and information/knowledge sharing would positively affect supply chain transparency, which in turn would boost overall supply chain performance. Although participants in this study clearly expressed similar positive attitudes around the technology's capacity to enhance traceability and transparency, they pointed out that digitising physical aspects of the supply chain could prove a challenging process. Here the integration of IoT devices (Nikolakis et al., 2018) and AI (Saberi et al., 2019) will play an essential complementary role in reliably resolving this challenge and achieving the broader goal of hyper transparency discussed in the literature review chapter. This notion is also supported by the views of industry professionals in Friedman & Ormiston's (2022) study, who suggested that such complementary technologies will be crucial in ensuring data trustworthiness.

Another area where participants in this study expressed a more moderate attitude is the regulatory compliance aspect of the technology. Although there was general agreement on providing partial blockchain ledger access to regulators for compliance purposes and that such process will not jeopardise business practices and/or competitive advantage, participants adopted a neutral stance regarding the positive impact government regulation has on SCM. This finding, in combination with the fact that one of the most significant barriers to adoption was the regulatory uncertainty around the technology, which is also the case in other studies (Pai et al., 2018; Petersen et al., 2018), implies that the way with which governments and institution will legislate and the direction this potential regularity framework will take might prove a determining factor for a company's decision to fully implement the technology for their business. Therefore, the initial assumption made in the literature review that blockchain applications in SCM have fallen into an institutional void might prove substantial.

It is also noteworthy that when examining participants' scores on the four blockchain areas of interest based on their sector, some variations exist despite the overall positive scores across all five represented industries. For instance, participants from the logistics and transportation industry scored lower on traceability and regulation, while those from the energy sector similarly exuded the most neutral scores on trust and relationship management. Food industry professionals had the most positive stance on traceability, while aviation companies reported the most positive scores on trust and regulation compliance. This variation links back to the comments discussed earlier by Buterin (2015), which suggested that blockchain technology is not a panacea, "one size fits all" solution, but that each industry will need to be examined individually and adopt a different approach and implementation.

The results of the decision-making flowchart further drive this point home. Blockchain was an appropriate solution for five participants, each representing one of the sectors represented in this study (Table 7), with private permissioned and permissionless blockchain being the two outcomes. The points of differentiation for participants seem to cluster around the presence of a trusted party for verification purposes, who gets to participate in the system and the level of trust towards them. This tension around the nature of participation was already evident since participants reported the lack of trust among users as the main barrier to blockchain SCM adoption, privacy as the primary regulatory concern and the existence of established frameworks and policies as the main criteria for joining a consortium. Therefore, although participants expressed favourable views around the blockchain aspects examined and the technology's ability to deliver them, a clear structure around the nature and identity of who gets to participate in the blockchain system and developing a well-defined framework and policies to enable trust and collaboration also emerge as key considerations for blockchain organisations.

The study's first limitation revolves around the relatively small sample size. One must take into consideration, of course, that the pool of potential companies experimenting and/or implementing blockchain for their supply chains is limited to begin with, and, as the data demonstrated, a substantial amount of them are in the research stage, suggesting a possible reluctance to engage in such survey. Additionally, data collection occurred right in the midst of the COVID-19 outbreak, which significantly shifted companies' priorities and availability. Although the nature of the study was exploratory, future research with a larger sample size and potentially from a wider variety of sectors will be needed in order to allow both for greater external validity as well as more robust comparisons between industries. The second limitation concerns the research method selected for the study. Despite the survey being more than a satisfactory tool for the purposes of the study, it did not allow to delve deeper into some of the participants' responses (e.g., uncertainty around regulatory frameworks). Therefore, future work utilising the initial design for this study, which involved semi-structured interviews (as discussed in Chapter 3), might be able to uncover themes and underlying reasoning undetected by the survey.

4.5 Conclusions

The main goal of this study was to address the two elements of this PhD's first research question that asked a) which aspects and characteristics of blockchain applications in supply chain management are most relevant to industry decision-makers and b) does their organisation needs to adopt and implement the technology.

The findings of this study suggested blockchain features around traceability and transparency, quality control, as well as information sharing, and collaboration were favoured the most, while questions around regulation and compliance, or the lack thereof, along with the need for a clear structure and policies around who gets to participate in the network were of most concern to industry decision-makers. At the same time, whether an organisation actually needs to implement blockchain in their supply chain will depend not only on addressing the above-mentioned challenges but also on their industry's specific circumstances, demands, and idiosyncrasies.

On a research level, this study provided a much needed and currently absent perspective of the industry professionals' views on blockchain applications in SCM that goes beyond the technical development and structure of the technology and provides a window on the variety of possible reasons that can affect the technology's adoption and further commercialisation. It also provided empirical evidence for the use of Wüst & Gervais's (2018) decision-making flowchart, which, although not purposed to be the solely tool in a professional's arsenal when deciding to adopt the technology, can provide valuable insights and potential points of interest that can greatly assist in the process.

At the same time, these findings can be of great value for both commercial organisations as well as governments and regulators. On the one hand, realising the importance of information sharing and the establishment of robust collaboration frameworks needs to come at the forefront of an organisation's evaluation of using blockchain for its supply chain. On the other hand, institutions could significantly accelerate that process by providing the appropriate regulatory environment. This last point will be further discussed in this thesis's general discussion (Chapter 7).

While the views of industry professionals around blockchain for SCM transparency and traceability cover one aspect of this work, the next chapter will examine the case of using blockchain technologies for coffee traceability certification and the perspective of one of the most important stakeholders: the end consumer.

5 Study 2: Examining the Influential Factors of Consumer Purchase Intentions for Blockchain Traceable Coffee Using the Theory of Planned Behaviour

5.1 Introduction

As discussed in the literature review chapter, despite the overall interest in blockchain and its potential to enhance supply chain transparency, current research on the topic has mostly focused on conducting scenario analysis and developing the technical infrastructure required for these systems (Nie & Luo, 2019). Very little attention has been given to exploring consumers' purchasing intentions for products based on blockchain traceability systems, the factors influencing those intentions and how they compare with existing traceability solutions. To bridge that research gap and set the opening scene in answering this PhD's second research question, this study will investigate consumers' purchasing intentions and their psychosocial antecedents utilising an extended model of the TPB, depicted in Figure 13. To achieve that aim, I conducted an online questionnaire among 123 participants using two traceability systems (one based on blockchain and one on a more traditional certification) for organic coffee.

Blockchain technologies offer the potential to streamline supply chains processes, make production and business practices more transparent (Hastig & Sodhi, 2020), and pass those benefits directly to an end consumer that is increasingly concerned about sustainability issues and fair-trade of their coffee (H. Lee et al., 2018). Therefore, filling the abovementioned research gaps utilising and expanding an established framework in consumer food choice (Nardi et al., 2019), that is the TPB, will ensure that the design of these new systems will be built not only around addressing the technical and logistical challenges coffee farmers and producers face but, at the same time, also addressing current consumers' needs and concerns.

Since purchasing intentions have been found to signal actual purchasing behaviour (Yang, 2021) and, more importantly, retain existing and attract new customers (Morwitz, 2012), establishing the variables that predict them when it comes to blockchain traceable coffee can benefit all actors in the coffee value chain. That is, benefit both for businesses that can design their traceability systems based on their customers' requirements and current market trends, and for consumers that can feel confident the product they are buying is in line with their values and lifestyle.

Apart from answering this PhD's second research questions, the study's overall aim is to also contribute towards the role psychosocial variables play in explaining purchase intentions for blockchain traceable coffee and how such variables could contribute towards the design of the relevant blockchain applications. On a secondary level this study aims to reaffirm the validity of TBP in predicting purchasing intentions in the food choice context and establish additional factors that could increase the model's predictive power.

In the next section, I will provide a description of the materials and methods employed in this research (5.2), followed by the results of the questionnaire study (5.3) and a discussion of its findings (5.4). Finally, I conclude with the study's implications (5.5) both on a practical level of presenting traceability information and increasing consumer awareness on traceability systems as well as on a research level of expanding the product and system range the TPB can explain and variables that can increase the model's predictive power. Future research suggestions are also provided.

5.2 Materials and Methods

5.2.1 Data Collection and Sample Description

An online questionnaire involving a convenience sample of 123 participants (61% response rate) was conducted during September - October 2020 via the online platform Callforparticipants.com and via emailing lists (students and staff) at the University of Nottingham. All responders had to be above 18 years old and consume at least 1-2 cups of coffee per week. At the beginning of the questionnaire, participants were informed about the project's funders and that the study had no commercial motives. It was also emphasised that were no wrong or right answers and that all data collected will be treated anonymously and in line with Nottingham University's guidelines. The research design was approved by the Nottingham University Business School Ethics Committee, and consent was obtained from each participant at the beginning of the study.

Table 8 contains the demographic details of the sample and their characteristics. The majority of participants drink at least one coffee cup per day (77.2%), but they were equally split in their familiarity with coffee certification schemes. Most of the responders have heard of food traceability systems (68.3%), and they are aware that such systems can provide additional information to consumers (65.9%). However, almost half of the participants are unaware that food traceability systems could prevent food risks (48%) and track safety problems (43.9%). Finally, most of the sample have heard of blockchain technologies (63.4%).

5.2.2 Definitions and Visual Examples of Blockchain and UTZ Coffee

Upon granting consent, filling out their demographic information, and answering the questions regarding their familiarity with traceability systems, participants were given a short set of instructions regarding the questionnaire's next steps. They were then presented with two different traceable coffee products (both products are fictional and were created for the purposes of the study), one with a conventional traceability certification scheme (UTZ) and another based on blockchain traceability certification (Figure 34). As already discussed, UTZ was chosen as the conventional certification scheme because it is the most extensive program for sustainable coffee (UTZ, 2017). The products were otherwise the same apart from their traceability label.

In order to set a basic information background among participants, both products were accompanied by a detailed description of what exactly its system offers and how it operates. These descriptions included a brief history of each system, what it does and how it works, as well as its advantages and disadvantages. For the blockchain traceable product, participants were also offered a visual aid, depicting the website they would view when they scan the QR Code, which contained production details and the product's journey (Figure 35). The visual aid design was based both on commercial blockchain traceability applications (iFinca, 2020; Project Provenance, 2015) as well as on the application proposed by Pradana et al. (2020). Adopting such design made sure that participants had at least a sufficient amount of information for both products before answering the questions and thus addressing Sirieix's et al. (2013) concerns that although consumer might recognise the label and what it represents, they do not have complete information of what it means.

Table 8.

Demographics and Characteristics of the Study Sample

		N=123 %
Gender	Male	41.5
	Female	53.7
	Non-binary	3.3
	Prefer not to say	1.6
Age	18-29	47.2
	30-39	35
	40-49	13
	50-59	4.9
Education	GCSE	3.3
	A-level	8.9
	BSc degree	26
	MSc degree	41.5
	PhD	20.3
Employment	Employed full time	35.8
	Employed part time	13.0
	Unemployed	4.1
	Student	43.9
	Prefer not to say	3.3
Coffee Consumption Frequency	1-2 Cups a day	50.4
	More than 2 cups a day	26.8
	1-2 Cups a week	6.5
	3-4 Cups a week	6.5
	Less than a cup a week	9.8
Are you familiar with sustainable coffee certification schemes	Yes	52
	No	48
Have you ever heard of food traceability systems?	Yes	68.3
	No	31.7
Do you know that food traceability systems can prevent with food safety risks?	Yes	52
	No	48
Do you know that food traceability systems can track food safety problems?	Yes	56.1
	No	43.9
Do you know that food traceability systems can provide information to consumers?	Yes	65.9
	No	34.1
Have you ever heard of blockchain Technologies?	Yes	63.4
	No	36.6
Willingness to Pay (WTP)	Yes	75.6
(Yes, if participants were willing to pay more for blockchain coffee than the standard price)	No	24.4

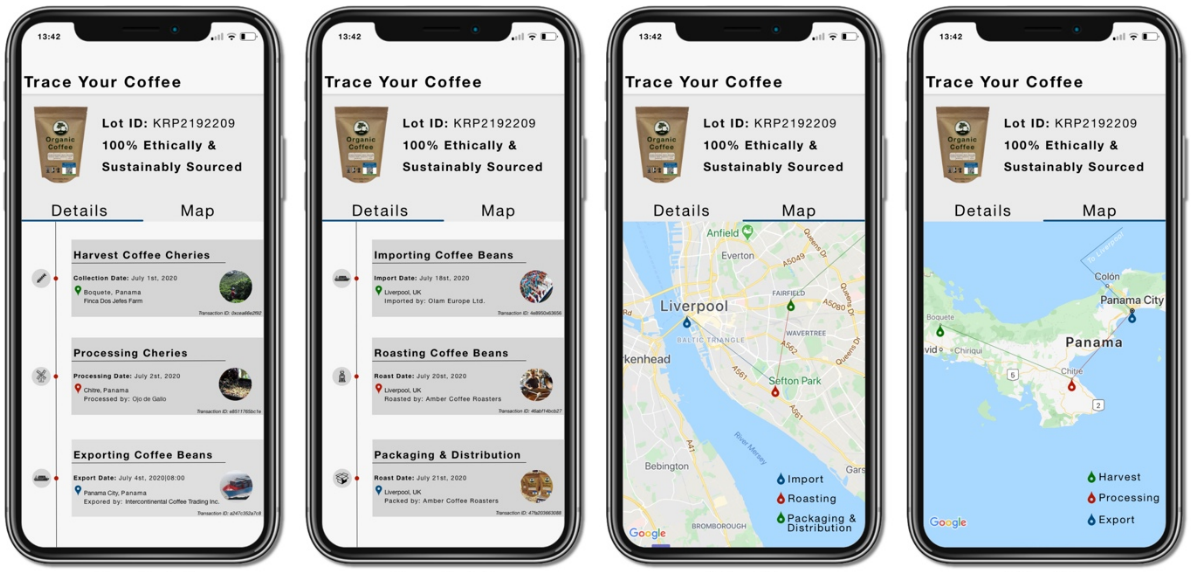
Figure 34.

Organic Coffee Visual Aids (Blockchain and UTZ)

Note. Full size images of the products and their descriptions can be found in Appendix 2.

Figure 35.

Blockchain Traceability App Visual Aid



Details 1/2 *Details 2/2* *Map 1/2* *Map 2/2*

Note. Full size images of the app visual aid can be found in Appendix 2.

5.2.3 Questionnaire Design and Measures

Following the product descriptions and the visual aid, participants answered the main questionnaire. The questionnaire items were developed drawing on guidelines proposed by Ajzen (1991, 2006) on how to structure a TPB questionnaire as well as on previous research on using the TPB model to explore food traceability (K. H. Lee et al., 2015; Menozzi et al., 2015; Spence et al., 2018). The questionnaire contained closed-ended questions, and items (listed in Table 9) were scored on a 7-point Likert-type scale (1 = “Strongly Disagree” – 7 “Strongly agree”) unless otherwise indicated.

Attitudes towards purchasing traceable blockchain coffee compared to UTZ certified traceable coffee were measured using a four semantic differential scale covering both the affective (bad-good, displeased-pleased) and the cognitive (foolish-wise, harmful beneficial) aspects of attitudes. Five social norms were used to assess the perceived social pressure (subjective norms) of purchasing blockchain traceable coffee, including family, scientists, media, the food industry and important others. The participants' ability to acquire and comprehend information on production processes and origin (Perceived Behavioural Control - PBC) regarding blockchain traceable coffee was assessed using six items.

Three types of purchasing habits were assessed, namely, country of origins, production processes and food assurances ("[When buying coffee, behaviour X is something ...]" "I do automatically", "I do without having to consciously remember", "I start doing before I realise I am doing it", "I do without thinking"). Trust was evaluated on three items, including trusting the information about the product's place of origin, production processes and authenticity. Four items were used to measure the participant's perception of environmental standards regarding blockchain traceable coffee. Purchasing intention was measured by three items: "[When blockchain traceable coffee becomes available...]" "I intend to buy it", "I will look for it", "It will be important to me to buy it". Finally, behavioural beliefs were assessed on nine statements, in which participants had to compare blockchain traceable coffee to certified traceable coffee on whether they believe it will be healthier, tastier, more expensive, safer, more satisfying, authentic, more environmentally friendly and of higher productions standards.

Table 9.

Means (SD), Cronbach's Alpha, and Standardised Factor Loadings of Questionnaire Items

Variables (No of items)	*Mean (SD)*	*Alpha*	*Factor Loadings*
Attitudes (4 Items)	4.78(1.30)	0.94	
Buying Blockchain traceable coffee instead of UTZ certified coffee would make me feel:			
Scale: bad (1) - good (7)	4.83(1.47)		0.86
Scale: displeased (1) - pleased (7)	4.87(1.44)		0.87
I think that buying blockchain traceable coffee instead of UTZ certified coffee is:			
Scale: foolish (1) - wise (7)	4.76(1.29)		0.72
Scale: harmful (1) - beneficial (7)	4.65(1.46)		0.84
Subjective Norms (5 Items)	4.02(1.27)	0.84	
I would buy blockchain traceable coffee because:			
My partner, family and friends approve of it.	3.83(1.63)		0.77
The scientific community is in favour of it.	5.03(1.59)		0.46
The media (TV, radio, social media) are in favour of it.	3.47(1.62)		0.70
My partner, family and friends approve of it.	3.68(1.69)		0.74
People important to me buy/prefer this type of coffee.	4.11(1.66)		0.80
Perceived Behavioural Control (6 Items)	5.22(1.89)	0.94	
Regarding the additional information about the production processes and origin of the blockchain traceable coffee (obtained via the QR code):			
It will be easy to find/obtain the additional information	5.52(1.58)		0.73
I will be confident that I will find/obtain the additional information	5.31(1.50)		0.54
I will be able to find/obtain the additional information without the help from others.	5.43(1.54)		0.80
It will be easy to understand the additional information	5.08(1.63)		0.89
I will be confident that I will find the additional information	5.00(1.57)		0.93
I will be able to understand the additional information without help from others	4.99(1.66)		0.89
Habits: Country of Origin (4 Items)	3.81(1.92)	0.95	
When I buy coffee, looking for information about the country or region of origin is something:			
I do automatically	4.11(2.15)		0.80
I do without having to consciously remember	3.89(2.06)		0.82
I start doing before I realise I am doing it	3.70(1.99)		0.77
I do without thinking	3.58(2.07)		0.77
Habits: Production Process (4 Items)	2.92(1.64)	0.95	
When I buy coffee, looking for information about the production process that is needed to make the coffee (e.g., harvesting, processing, roasting etc) is something:			
I do automatically	2.99(1.72)		0.85
I do without having to consciously remember	2.97(1.77)		0.79

I start doing before I realise I am doing it	2.83(1.76)		0.87
I do without thinking	2.89(1.79)		0.85
Habits: Food Assurances (4 Items)	3.76(1.82)	0.96	
When I buy coffee, looking for food assurance schemes, such as UTZ, FairTrade or smaller 'niche' schemes that aim to meet particular consumer demands such as higher environmental or organic standards or good business practices, is something:			
I do automatically	3.99(1.97)		0.92
I do without having to consciously remember	3.84(1.95)		0.92
I start doing before I realise I am doing it	3.62(1.88)		0.96
I do without thinking	3.58(1.87)		0.89
Trust (3 Items)	5.08(1.27)	0.92	
I trust:			
That blockchain traceable coffee can be tracked back to the actual plantation	5.28(1.38)		0.75
The information provided about the production process and origin of the blockchain traceable coffee	5.12(1.32)		0.74
Blockchain traceable coffee is authentic, which means it has not been tampered with in any way and is what it says it is	4.84(1.42)		0.66
Environmental Protection (4 Items)	3.89(1.47)	0.93	
Regarding blockchain traceable coffee, in comparison to UTZ certified coffee available in the market:			
Blockchain traceable coffee is produced without breaking the balance of nature	3.63(1.61)		-0.79
Blockchain traceable coffee promotes environmentally friendly packing procedures	3.91(1.48)		-0.71
Blockchain traceable coffee promotes environmentally friendly production processes	4.04(1.54)		-0.69
Blockchain traceable coffee is produced with environmental protections in mind	4.00(1.72)		-0.71
Intentions (3 Items)	4.18(1.58)	0.89	
When blockchain traceable coffee becomes available:			
I intend to buy it	4.32(1.69)		-0.81
I will look for it	4.82(1.88)		-0.91
I will be important to me to buy it	3.41(1.65)		-0.63
Behavioural Beliefs (9 Items)	4.21(1.29)	0.93	
Regarding blockchain traceable coffee, in comparison to UTZ certified coffee available in the market:			
Blockchain traceable coffee will likely be healthier	3.56(1.64)		0.57
Blockchain traceable coffee will§ likely be tastier	3.35(1.54)		0.55
Blockchain traceable coffee will likely be more expensive	4.51(1.43)		0.53
Blockchain traceable coffee will more likely be of known origin	5.25(1.56)		0.64
Blockchain traceable coffee will likely be safer	4.46(1.59)		0.66
Blockchain traceable coffee will likely be of more satisfying quality	3.82(1.62)		0.62
Blockchain traceable coffee will more likely be authentic which means it has not been tampered with in any way and it is what it says it is	4.61(1.59)		0.67
Blockchain traceable coffee will likely be more environmentally friendly	4.00(1.77)		0.53
Blockchain traceable coffee will likely have higher production standards	4.32(1.86)		0.58

Note. Item Were Scored on a 7-Point Likert-Type Scale (1: "strongly disagree", 7: "strongly agree", unless otherwise indicated).

At the end of the questionnaire, participants were also asked the following question (adopted from Spence et al. (2018)) regarding how much more they are willing to pay (WTP) for blockchain traceable coffee, as a percentage of the conventional product price: "*Suppose the price of organic coffee currently available in the supermarket is £3.05 for a 250g pack. The price of the blockchain traceable coffee with the unique identity details and the additional available information will be higher, but it is not determined yet. How much more would you be willing to pay to purchase 250g of blockchain traceable coffee?*". Participants then chose their preferred WTP from the following range of options: 0% - 25% in increments of 5 and 30% - 100% in increments of 10.

5.2.4 Data Analysis

All data analysis was conducted using IBM Statistics for macOS, Version 27.0. A p-value $p < 0.05$ was considered to be significant. To begin with, factor analysis was conducted to make sure the underlying structures of the original scales proposed remain true, followed by a reliability analysis on each of the factors. Next, a hierarchical multiple regression examined the relationship between TPB model constructs and intention to purchase blockchain traceable coffee. I then tested the extended version of TPB, which included habits, trust, and environmental protections. Finally, Pearson correlations measured the strength of the relationship between constructs within the models, behavioural beliefs and attitude, and behavioural beliefs and intention.

5.3 Findings

5.3.1 Factor Analysis

At the first stage, a Principal Component Analysis with OBLIMIN rotation was performed on the questionnaire's 46 items. Multicollinearity was not an issue, as revealed by the correlation matrix, while the Kaiser–Meyer–Olkin (KMO) measure verified the sampling adequacy for the analysis (KMO = 0.85). Based on Kaiser's criterion on retaining factor with eigenvalues greater than 1, the analysis yielded a 10-factor solution which, in combination, explained 80.9% of the variance. The extracted communalities range from 0.54 to 0.91, with the average communality being 0.80. This solution is also in line with the literature the questionnaire was based upon. Each variable cleanly loaded onto one factor above the recommended level of 0.40.

A reliability analysis (Cronbach's α) was also performed for each of those factors. All values are above the recommended level of 0.70. (No values less than 0.30) and none of the values in the Cronbach’s Alpha if Item Deleted analysis are above the overall a. Table 9 shows the factor loadings along with internal reliabilities.

5.3.2 Descriptive Summary

Participants reported a high level of PBC, especially in their ability to obtain additional information from the blockchain traceable coffee and do so with confidence and without help from others. They also expressed a considerable degree of trust towards the information provided regarding production processes and that the coffee can be traced back to the actual farm. There was a generally favourable attitude for the blockchain traceable coffee, with participants stating that buying it would be wise/beneficial and make them feel pleased/good.

Participants also reported positive behavioural beliefs, particularly regarding blockchain traceable coffee being of know origin, more expensive and has not been tampered with throughout the production process. However, they did not believe it will be healthier or tastier. Subjective norms were slightly positive, with the scientific community having the most significant influence in buying the blockchain traceable coffee. The same level of agreement was expressed for environmental protections, with participants reporting that blockchain traceable coffee promotes environmentally friendly production processes and protections compared to UTZ coffee.

Intentions to purchase blockchain coffee when it becomes available were also positive, with participants reporting that they will look for it and intent to buy it, but this purchase will be of neutral importance. Country of origin and food assurances habits were centred around the midpoint while habits regarding production processes fell to lower levels. Finally, when asked how much more they are willing to pay above the base organic coffee price, 75.6% of participants indicated that they are willing to pay at least 5% more for the blockchain traceable coffee, with the majority indicating a price premium ranging from 5% - 30% of the base price.

5.3.3 Predicting Purchasing Intentions

A hierarchical multiple regression examined the association between TPB model constructs (attitude, subjective norms and PBC) and intentions to purchase blockchain traceable coffee. Then, the extended version of the TPB model was tested, including habits, trust, and environmental protections. Before performing the analysis, I checked for potential bias in the model. Inspecting the plot of standardised predicted values against standardised residuals revealed no concerns regarding linearity and homoscedasticity. Checking the correlations between the constructs (Table 10) suggests there is no multicollinearity in the data ($r > 0.90$), with the highest significant correlation being between trust and PBC ($r = 0.62$, $p < .001$). Finally, no influential outliers were found on the dependent or the independent variables.

Table 10.

Correlations Between Intentions and All Other Constructs Within the TPB and Extended TPB Models

Constructs	1	2	3	4	5	6	7	8	9
1. Intentions	-								
2. Attitude	**0.54*** **	-							
3. Subjective Norms	**0.39*** **	**0.49*** **	-						
4. Perceived Behavioural Control	**0.46*** **	**0.50*** **	**0.44*** **	-					
5. Habits (Country of Origin)	**0.25** **	0.01	0.03	-0.08	-				
6. Habits (Production Process)	**0.29*** **	0.05	0.01	-0.03	**0.67*** **	-			
7. Habits (Food Assurances)	**0.26** **	-0.01	**0.17* **	-0.02	**0.48*** **	**0.45*** **	-		
8. Trust	**0.43*** **	**0.50*** **	**0.48*** **	**0.62*** **	0.14	0.05	0.09	-	
9. Environmental Protection	**0.59*** **	**0.61*** **	**0.42*** **	**0.41*** **	0.15*	**0.25** **	**0.18* **	**0.46*** **	-

Note. p ≤ 0.05*; < 0.01**; < 0.001***; numbers in bold indicate significance.

Table 10 contains the correlations between the model constructs. All variables correlated significantly with the intention to purchase blockchain traceable coffee. Environmental protection, attitude and PCB had the strongest positive correlations with attitudes, indicating that having a positive evaluation about the blockchain traceable coffee, feeling able to understand the additional information and holding favourable views regarding its environmental protections will make the intention to purchase it more likely. On the other end, all three habits recorded the lowest correlations with intentions.

For the first model in the hierarchical regression, attitudes, subjective norms and PBC are used as predictors (Table 11). The *R* value is 0.59, with an R^2 value of 0.34 and an R^2_{adj} of 0.33, indicating that this model accounts for 33% of the variance in purchasing intentions. Additionally, this prediction is statistically significant $F\,(3, 119) = 20.80, p < 0.001$. Habits, trust, and environmental protections were added as predictors for the second model in the hierarchical regression. For the extended TPB model, the *R* value is 0.70, with an R^2 value of 0.49 and an R^2_{adj} of 0.46, meaning that adding these predictors increased the variance in intentions to 46%. This prediction is also statistically significant $F\,(5, 114) = 6.71, p < 0.001$.

Table 11.

Standardised Regression Weights (β) for TPB and Extended TPB Constructs

Independent Constructs	**TPB**			**Extended TPB**		
	B	*SE B*	*β*	*B*	*SE B*	*β*
Attitude	**0.45**	**0.11**	**0.37*****	**0.28**	**0.11**	**0.23***
Subjective Norms	0.13	0.11	0.10	0.04	0.10	0.03
Perceived Behavioural Control	**0.26**	**0.10**	**0.23****	**0.28**	**0.10**	**0.24****
Habits (Country of Origin)				0.09	0.08	0.12
Habits (Production Process)				0.09	0.09	0.09
Habits (Food Assurances)				0.10	0.07	0.12
Trust				-0.03	0.12	-0.2
Environmental Protections				**0.31**	**0.10**	**0.28****
R^2_{adj}	0.33			0.46		
F	**20.83*****			**13.88*****		
ΔR^2	-			0.15		

Note. $p \leq 0.05$*; < 0.01**; < 0.001***; numbers in bold indicate significance.

5.3.4 Explaining Purchasing Intentions

To further understand the reasons influencing the intention to purchase blockchain traceable coffee, the behavioural beliefs were correlated with attitudes and intentions. Table 12 illustrates that for all behavioural beliefs, there was a significant positive correlation ($p < 0.001$) both with attitudes and intentions. Blockchain traceable coffee will have higher production standards, be more environmentally friendly and is likely to be safer had the highest positive correlation with attitude, while beliefs that this coffee will have more satisfying quality, be more environmentally friendly and has not been tampered with had the highest positive correlations with intentions.

Table 12.

Correlations of Behavioural Beliefs with Attitude and Intentions

Behavioural Beliefs	**Correlations (*r*) with Attitude**	**Correlations (*r*) with Intentions**
Blockchain traceable coffee will likely be healthier	0.45*	0.47*
Blockchain traceable coffee will likely be tastier	0.43*	0.47*
Blockchain traceable coffee will likely be more expensive	0.44*	0.35*
Blockchain traceable coffee will more likely be of known origin	0.48*	0.45*
Blockchain traceable coffee will likely be safer	0.57*	0.47*
Blockchain traceable coffee will likely be of more satisfying quality	0.55*	0.53*
Blockchain traceable coffee will more likely be authentic which means it has not been tampered with in any way and it is what it says it is	0.55*	0.47*
Blockchain traceable coffee will likely be more environmentally friendly	0.58*	0.52*
Blockchain traceable coffee will likely have higher production standards	0.59*	0.44*

Note. *$p < 0.001$.

5.4 Discussion

The numerous food safety incidents over the past decade led governments and companies to the realisation that an up-to-date traceability system is a vital prerequisite for regaining consumer confidence and succeeding in the food industry's ever-changing landscape. At the same time, these incidents created consumer expectations that they will be able to access quality and traceability information when making purchasing decisions. Since observing the positive signs of blockchain implementations in other industries (e.g., finance), supply chain actors started implementing the technology in their systems in an attempt to enhance traceability and transparency in the food industry. The aim of this study was investigating the attitudes and intentions to purchase blockchain traceable coffee and identify the psychosocial determinates of these purchasing intentions using the TPB and testing an extended TPB model.

The research revealed that participants' confidence in their ability to find and understand the additional product information and do so without any help were the most positive connections to traceable blockchain coffee, followed by the trust that the coffee can be traced back to the actual farm and the belief that blockchain traceable coffee is more likely to be of known origin. This finding is in line with Spence et al. (2018) that reported analogous high PBC scores when investigating a similar (but not based on blockchain) traceability system for beef. The high scores reported for the place of origin and confidence that the coffee can be traced back to the farm are also in line with previous research in meat and honey items (Menozzi et al., 2015; Spence et al., 2018; Van Rijswijk et al., 2008).

The TPB model explained 33% of the purchasing intention variance while adding the new variables increased its predictive power to 46%. The first finding aligns with the meta-analysis Armitage and Conner (2001) conducted and found that among 185 independent studies, TPB variables accounted on average for 39% of the variance in intentions, as well as with previous research (Giampietri et al., 2018; Menozzi et al., 2015; Sayogo et al., 2018) which reported a range between 28% and 39%. For the TPB, attitudes and PBC were significant predictors of purchasing intentions, while subjective norms did not emerge as one. Although some researchers have reported that subjective norms is the least good predictor in the TPB model (McDermott et al., 2015) and others have even proposed that it is rarely able to predict intention and removed it from their research (Armitage and Conner, 2001), in several studies subjective norms have emerged as a significant predictor (Giampietri et al., 2018; Menozzi et al., 2015; Sayogo et al., 2018; Spence et al., 2018). Further research, especially in the context of coffee and food traceability, is needed to establish this variable's role.

The additional variables accounted for a 13% increase in the predictive power of the TPB. However, only environmental protection emerged as a significant predictor, with trust and habits not predicting intentions. PBC and attitudes remained significant predictors, while subjective norms were not significant. This increase in the extended TPB's predictive power is in contrast with Menozzi et al. (2015) and Spence et al. (2018), who reported an increase between 2% and 5% in their extended models. While all three extended TPB models include trust and habits, this study's distinguishing factor was environmental protections, which emerged as the strongest predictor from the analysis. Previous literature has reported that environmental protections are a significant positive contributor towards attitude, subjective norms and PBC regarding organic coffee (Lee et al., 2015) but my research further suggests that this variable can also directly predict purchasing intentions.

Trust did not emerge as a significant predictor in the analysis, despite research emphasising its importance in purchasing intentions (Sander et al., 2018; Song et al., 2017). Other researchers have also reported mixed results regarding trust as a significant predictor in the extended version of TPB, with Menozzi et al. (2015) and Spence et al. (2018) reporting significant findings for some products and some countries but not for others, implying the potential effects of a product-specific and a cultural element. Future research might clarify the importance of that factor and dive deeper into potential moderation effects. Habits also did not emerge as significant predictors of purchasing intentions. Although previous research has demonstrated that past behaviour might function as a primer for future intentions, participants in this study reported low scores for habits regarding looking for information about production processes, food assurance and country of origin, confirming what Nie and Luo (2019) suggested that although consumers care about traceability, their cognition levels are low.

Another interesting detail from this study is participants' willingness to pay a price premium for blockchain traceable coffee. Although they believed that this type of coffee would be more expensive, 75.6% of participants indicated that they are willing to pay at least 5% more for the blockchain traceable coffee, with the majority price premium ranging from 5% to 30%. This finding aligns with a recent survey from IBM, in which 71% of participants who indicated that traceability is a crucial feature were willing to pay a premium for brands that provide it (Haller et al., 2020).

The main limitation of the study is the focus on purchasing intentions rather than actual purchasing behaviour. Although intentions account for a significant amount of behaviour (Ajzen, 1991), future research should consider investigating actual in-store purchases of blockchain traceable products. Another potential limitation is that most participants (63%) have heard of blockchain technology and were potentially aware of its benefits. Therefore, future research should investigate the responses blockchain traceability systems might elicit from participants less familiar with the technology. The next study in this thesis (Chapter 6) will attempt to address aspects of these limitations.

5.5 Conclusions

Apart from answering this PhD’s second research question, this study also contributes to the existing research on traceability systems, the consumer psychosocial attendances that drive purchasing intentions and expands that literature by looking at one of the most discussed technologies of today: blockchain. To my knowledge, this is the first study exploring consumer perception of blockchain traceable organic coffee using the TPB. Positive attitudes and PBC accounted for 33% of the variance in participants intention to purchase blockchain traceable coffee compared to its UTZ counterpart. The predictive power of the model increased to 46% when environmental protection was added. In contrast to literature suggestions, trust, habits, and subjective norms did not emerge as significant predictors.

On a research level, this study establishes the factors that affect consumer purchasing intentions for blockchain traceable products and specifically organic coffee, an understudied but increasingly prevalent area in the literature, especially as such products become more common in the market. Additionally, it further establishes the validity of the TPB in explaining purchasing intentions in the food choice context by expanding the product and traceability system range this model can reliably explain. I also provide evidence that factors such as environmental protections can be directly included in the model and significantly predict intentions and increase its overall predictive power.

On a practical level, the study has a threefold contribution. First, the format the additional product information was presented to participants (both for the general details in the systems and the visual information in the phone app) was highly effectual (as indicated by the high PBC scores) and could provide the basis for the user interface design of similar systems. Second, the emerging role of the environmental protections a product offers in predicting purchasing intentions is of particular interest to supply chain actors since it could function as a pilar both for designing features in their blockchain-based platforms as well as for marketing and promotion purposes. Finally, the confirmation of participants' low cognition level regarding traceability (as indicated by the low scores on all habits categories) suggests the importance that information campaigns (especially supported by the scientific community and significant others) around traceability, its significance and benefits could play in increasing consumer awareness, especially given the prominent role such increase can play in positively shaping purchasing intentions.

Ways in which blockchain's internal benefits can be transferred to the consumer, in which format, and how they affect their purchasing intentions compared to what already exists in the market, is a research area requiring further investigation, especially as this technology becomes more prominent in the market and more products adopt it for traceability and transparency purposes. The next chapter in this thesis will attempt to undertake such effort by examining how blockchain traceable coffee compares with other traceability certifications in the market.

6 Study 3: Blockchain Traceability Certification for Organic Coffee - Multiple Labels and Consumer Preferences

6.1 Introduction

It has been established throughout this thesis that there is a plethora of academic literature regarding the utilisation of blockchain and distributed ledger technologies for supply chain management, in general, and product provenance and traceability, in particular. Although this literature covers an area of different fields and provides a range of perspectives and standpoints, the view of the end consumer and what these technologies imply for them is generally limited in the literature (Schlegel et al., 2018), although a small number of studies are emerging as of lately (Nie & Luo, 2019; Sander et al., 2018).

That is especially the case when examining the use of blockchain for coffee traceability, with most of the literature focusing on this technology's technical/operational aspect. While a growing number of products are released in the mainstream market utilising this technology for coffee traceability and transparency purposes (e.g., Bext360, UCC Coffee, Fairfood), there is no research exploring consumer perceptions and acceptance for them. Additionally, although past studies have examined and compared consumer preferences and willingness to buy (WTB) for different coffee traceability certifications (Abdu & Mutuku, 2021; Basu et al., 2018; Van Loo et al., 2015), there is a complete lack of research in which blockchain traceability is included in the equation.

In an attempt to continue bridging this research gap while building on the insights of the previous chapter, this study will investigate consumer perceptions and preferences for blockchain traceable coffee and how they compare with other commercially available types of traceability certifications. To achieve that aim, an online experiment among 516 participants was conducted using five different versions of a traceable organic coffee product (Table 4 in Chapter 3), in which I recorded and compared their WTB along with a series of other measures such as their level of trust and how they evaluate each traceability feature. Furthermore, and to align with the aforementioned rise of the green consumer, I also explored participants' responses based on their level of environmental awareness.

Fulfilling the above-mentioned gap will have a two-fold contribution. First, on a research level, it will provide a much-needed theoretical perspective on how end consumers perceive the use of blockchain technology, whether they consider it a reliable mechanism for product traceability and provenance, how it stacks up against existing systems, and which features are most relevant to them. Second, on a practical level, it will provide evidence on how companies could better design and implement these systems beyond streamlining business processes and by taking consumer viewpoints, as well as current market trends, into account.

In the next section, I will formulate the hypothesis for this study, followed by a description of the materials, measures and methods employed throughout the research (6.2). I will then present the results of the online experiment and discuss its findings (6.3 and 6.4). Finally, I conclude with study implications on a theoretical and practical level and highlight some of the challenges blockchain technologies should overcome to achieve a wider backing among consumers (6.5). Future research suggestions are also provided.

6.1.1 Hypothesis Development

Based on the overall positive impact traceability certifications and additional product information have on consumers (Kher et al., 2010) and the increased price premium they are willing to pay for them (Hou et al., 2019), I expect that the addition of a traceability certification with the provision of additional product information will increase participants WTB compared to the organic coffee product with no traceability system initially presented. Specifically, I expect that participants in the two blockchain conditions (Condition D and E in Table 4) will report higher WTB compared to the rest of the conditions (H1). In addition, I expect participants in the conditions that provide additional traceability information on the product and certification processes (Conditions C, D and E in Table 4) to report higher WTB than participants in the groups that do not (H2).

I am also interested in exploring how participants perceive and evaluate each traceability system. Taking into account the consumer movement towards green consumption (K. White et al., 2019) and the subsequent demand for green credentials (EIT, 2020), as well as the initial positive consumer feedback for blockchain-based products that provide a more transparent view of their supply chain discussed in Chapter 5, I expect the conditions that provide additional product information will record higher scores in consumer evaluation of the system's attributes. Specifically, I expect participants to value the features offered in the blockchain conditions (Condition D and E in Table 4) more highly than the rest of the groups (H3). I also expect the same higher valuation of the features to hold true for the conditions that provide additional product information (Conditions C, D and E in Table 4) compared to the rest (H4).

Since the existence of a traceability system that provides credible product information can enhance consumer trust and increase their confidence in making food safety judgments (Lam et al., 2020), I believe that conditions in the study that provide additional product information will record higher levels of trust towards the product. In particular, I expect that participants in the blockchain conditions (Condition D and E in Table 4) will report higher scores on trust compared to the rest of the groups (H5) and participants in the conditions that provide additional information on the product (Condition C, D and E in Table 4) will report higher scores on trust compared to groups that do not (H6).

Finally, I want to explore whether specific consumer traits will affect their preferences for the traceability system. I am particularly interested in participants' level of environmental awareness (low/high) since, apart from being connected with positive purchasing behaviours and product exploration (K. H. Lee et al., 2015), the previous study demonstrated that the level of environmental protections participants believe a product offers can significantly predict their purchasing intentions. Therefore, I expect that participants with high environmental awareness will report higher scores in WTB, trust and system attribute valuation in all conditions, in general (H7), and for the blockchain conditions, in particular (H8), compared to participants with lower scores in environmental awareness.

6.2 Materials and Methods

6.2.1 Study Design

In order to explore consumer perceptions and attitudes towards different coffee traceability systems and test the hypotheses, I utilised an experimental design in the form of an online survey. Upon providing their consent and filling in some basic demographic data, participants were provided with the study information and instructions. A scenario was created in which they were informed that a newly established coffee roaster is releasing a new organic coffee product in the market and that the company is conducting market research and gathering people's thoughts and opinions before the official release of the product. The reason why I chose to create a setting with a fictional company for this study and not use an existing brand is to avoid any personal preferences participants might have towards a particular company and minimise response and familiarity bias in the data.

All participants were then presented with the organic coffee product without any traceability certification (No. 1 in Figure 36) along with a product description that highlighted the company's principles on environmental sustainability, social responsibility and FairTrade, as well as the processes it follows during production on aspects such as single-source beans, shade-grown and non-chemical practices. Participants were asked to state their WTB for this product and answer a comprehension check question. They were then randomly assigned to one of the five conditions described in Table 4 (Chapter 3) and presented with the same organic coffee but with the addition of the respective traceability certification on the product (represented with a logo) (Figure 36). As before, they additionally received a short but detailed description for each traceability certification, including a brief history of each system, what it does and how it works, as well as its advantages and disadvantages. A new visual design was also adopted for the coffee product to ensure all details are clear to participants and it corresponds to similar products in the market.

In the conditions that offered additional traceability information, participants were also provided with a visual aid depicting the supplementary product information they received when scanning the barcode/QR code on the product. For condition C this was in a format of an infographic (Figure 37) while for the two blockchain condition this was in format of a phone app (Figure 38 and 39). Adopting such an approach ensured that all participants had at least a sufficient level of knowledge about the traceability certification on their product before answering the next set of questions and thus addressing the concerns expressed by Sirieix et al. (2013), who, as discussed earlier, suggested that although consumers might be able to recognise a label and what it represents, they rarely have complete information of what it truly means.

Figure 36.

Organic Coffee Product and Traceability Certifications

Note. 1 = No traceability certification, 2 = Condition A, 3 = Condition B, 4 = Condition C, 5 = Condition D, 6 = Condition E; Full size images of the products and their descriptions can be found in Appendix 3.

Next, participants were asked to answer a series of questions regarding their trust towards the system they were just presented with, how they evaluate the features it offers, as well as restating their WTB and answering an additional comprehension check. These were followed by another set of questions measuring their environmental awareness and their knowledge and awareness around traceability systems. Finally, since the study measures WTB (i.e., intentions) and in an attempt to explore the existence of a possible intention-behaviour gap (referring to the misalignment of purchasing intentions and actual purchasing behaviour (Carrington et al., 2014)), a deception mechanism was deployed in which participants were informed that the company is offering them the opportunity to pre-order the organic coffee. They then could choose to place a pre-order or continue with the study (since this was a deception question both options led to the same next step of the study).

After this last step, participants were debriefed and informed about the real purpose of the study, the true nature of the deception question, as well as the reasons for creating such a fictional setting, and they were given details on how to raise any concerns or withdraw entirely from the study. Although deception mechanisms are a regular instrument in consumer research, they do raise ethical concern (Held & Germelmann, 2018). That is why the study design was scrutinised and approved by the Nottingham University Business School Ethics Committee before any data collection commenced.

6.2.2 Traceability Label Definitions and Visual Stimuli

As mentioned earlier, in designing the experimental conditions to explore how consumers will perceive a blockchain-based traceability system for coffee, I strived for a balance between the different approaches that already exist in the market and in the academic literature. Hence the design includes five different conditions (Table 4). These settings differ in three aspects: the type and provider of the traceability system, the visual logo on the product, and the provision (or not) of additional product information.

6.2.2.1 Condition A: Company Statement

When discussing the various coffee certification standards in the literature review, I touched upon how different companies, either in collaboration or individually, have started creating and promoting their own certification schemes and sustainability initiatives over the past years.

One might argue this is a natural progression for a sector that has been increasingly engaging in sustainability reporting and public disclosure of non-financial indicators around environmental performance in order to satisfy various stakeholders (see Bradley & Botchway (2018) for a comprehensive review). In the same line of thinking, this condition (No. 2 in Figure 36) included a sustainable initiative created by the newly formed coffee company and represented with their own logo on the product (the logo is fictional and was created for the purposes of this study).

The description participants received was based on existing coffee sustainability initiatives (Potts et al., 2014) and included details on how the company engages with various stakeholders and partners in its supply chain to ensure fair-trade principles and green production practices.

6.2.2.2 Condition B and C: Third-Party Certification and Third-Party Certification Interactive Barcode

These two conditions included traceability certifications based on a third-party organisation. I choose UTZ since it is one of the most extensive programs for sustainable coffee, an aspect that was greatly enhanced after the merger with Rainforest Alliance (Panhuysen & Pierrot, 2020). As discussed, UTZ certification also adopts a more holistic approach in its standards while having a particular focus on supply chain transparency (Bray & Neilson, 2017).

Participants in both conditions received the same description, focusing on the organisation's practices and standards, ways in which it ensures compliance, its advantages and disadvantages. The coffee product in condition B depicted the conventional UTZ logo (No. 3 in Figure 36) and did not provide any additional information.

Condition C included a version of the UTZ logo with a scannable barcode (No.4 in Figure 36). Since UTZ does not allow consumer access in its internal traceability system, the additional information participants received was based on an infographic that can be found in their website[2] and depicts the steps the organisation takes throughout its certification process (Figure 37).

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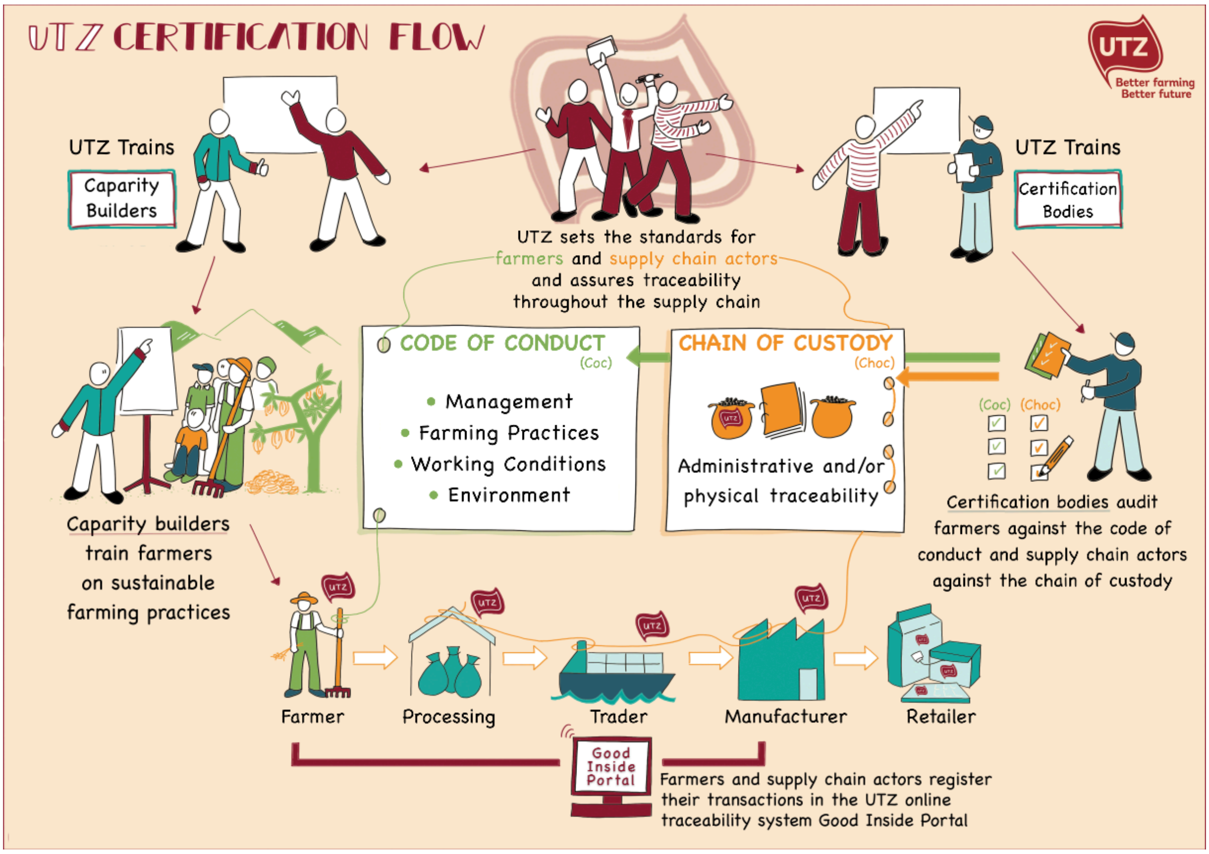
[2] https://www.rainforest-alliance.org/wp-content/uploads/2019/09/RA-Certification-flow-scaled.jpg.optimal.jpg

Figure 37.

Additional Traceability Information for Third-Party Certification (Condition C)



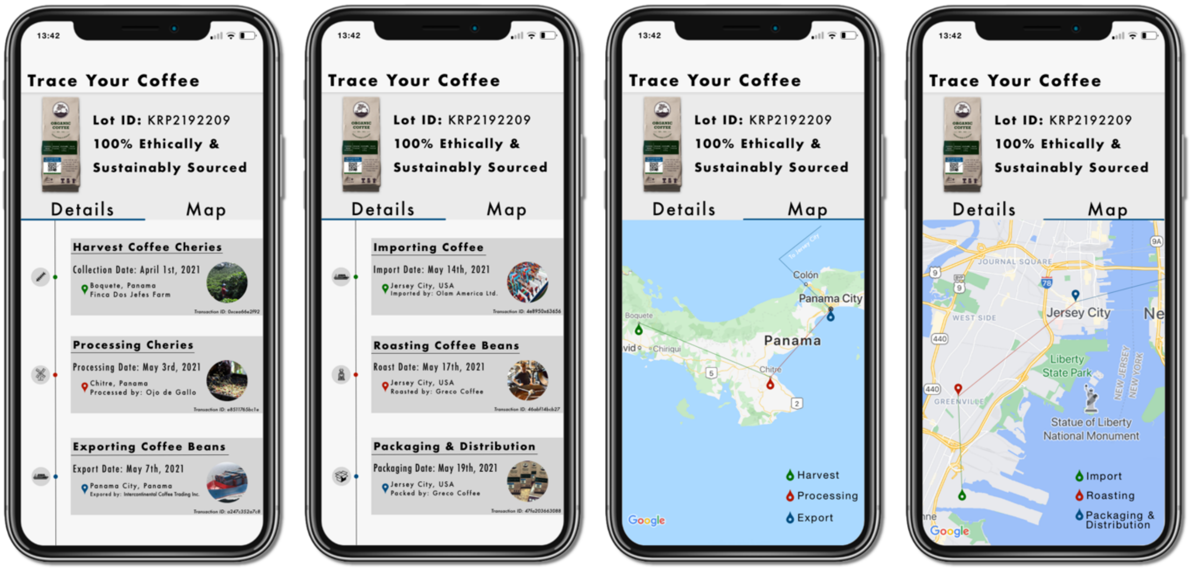
6.2.2.3 Condition D: Blockchain Platform

Since blockchain applications for coffee traceability have been proposed in the academic literature (Pradana et al., 2020) and several companies have already released solutions on the wider market (Brunt & da Costa Guimaraes, 2020; UCC Coffee, 2020), this condition was based on a combination of the features these platforms have proposed. Hence, the description participants received included some basic information on how this technology works, how it is being applied to track the coffee supply chain, as well as its downsides, such as the lack of an established framework of good practices third party certification, like UTZ, provide.

The QR code on the product acted as a logo (No. 5 in Figure 36), through which participants accessed the additional information presented to them in an app format (Figure 38). The app's design was based on the previous study (Chapter 5), which explored consumer preferences for blockchain traceable coffee and recorded high scores in participants' ability to comprehend the information provided, including all production steps and the product's journey from "farm to cup ". Since participant recruitment took place on Amazon MTurk and targeted participants from the USA, the app's map feature was changed from the previous study to a USA location.

Figure 38.

Additional Traceability Information for Blockchain Certification (Condition D)



Details 1/2 *Details 2/2* *Map 1/2* *Map 2/2*

Note. Full size images of the app visual aid can be found in Appendix 3.

6.2.2.4 Condition E: Blockchain Platform and Third-Party Certification

As discussed by Balzarova (2021), certification labels and blockchain applications for traceability purposes are not mutually exclusive. On the contrary, since blockchain can also be seen as a foundational rather than a disruptive technology (Iansiti & Lakhani, 2017), these two approaches can complement each other and account for their shortcomings. Such an example can be seen in the collaboration between the digital platform Provenance and cosmetics retailer Cult Beatty, which utilises the former's blockchain traceability system while also incorporating the retailer's Forest Stewardship Council (FSC) certification for its traceable products (Douglas, 2022). This is also an established practice in the coffee industry since the trend pushing producers towards acquiring multiple certifications has resulted in coffee packages caring multiple traceability and/or sustainability labels (Van Loo et al., 2015).

In the same line of thinking, this setting combines the two aforementioned conditions with a blockchain traceability system for tracking the organic coffee while some of the supply chain steps are verified by UTZ. The description participants received was also based on the ones used before, with a short explainer around blockchain technologies and UTZ as well as how these two approaches interact. That was also the case for the logo on the product, with the blockchain QR code being accompanied by UTZ's logo (No. 6 in Figure 2). Finally, the additional information participants received followed the format of the previous setting with the addition of UTZ certification for the farming conditions (Figure 39).

Figure 39.

Additional Traceability Information for Blockchain/Third-Party Certification (Condition E)

Details 1/2 *Details 2/2* *Map 1/2* *Map 2/2*

Note. Full size images of the app visual aid can be found in Appendix 3.

6.2.3 Study Measures

The measures used in this study were designed based on validated scales used in previous research. All measures contained closed-ended questions and all items (Listed in Table 14) were scored on 7-point Likert scales. Anchors were also varied across all measures, and in line with the original scales, in an attempt to avoid common method bias (Podsakoff et al., 2003).

6.2.3.1 Dependent Measures

Willingness to Buy (WTB): Participants' purchasing intention consisted of four items, measured before and after exposure to the traceability certification. They were based on a scale originally proposed by Baker & Churchill (1977) and which have been extensively used in the literature to access the conative dimensions of purchasing attitudes towards a variety of products

(Griffith & Chen, 2004; Okechuku & Wang, 1988). It includes questions on intentions and willingness to try, seek, buy, and patronise the organic coffee product in-store or online.

New (Product) Attributes Relative Advantage (NARA): Participants' evaluation of the added traceability system was measured using six items, designed based on scales proposed by Rijsdijk et al. (2007) and Mukherjee & Hoyer (2001). The scale was administered after participants saw the traceability systems. It included aspects on whether they believed the product now offers an advantage compared to products on the broader market and whether its new features (in my case, the traceability certification) provides additional benefits and value to the product.

Trust: Participants' trust towards the product was also measured after they were exposed to the traceability system, and it was based on the scale used in Chapter 5 (Adopted from Menozzi et al. (2015)). It includes questions about participants' trust in the information they received regarding the product's origin, production processes, and authenticity.

6.2.3.2 Additional Measures

Environmental Awareness: The degree to which participants are environmentally conscious regarding their consumption and purchases was measured using six items drawn based on the GREEN scale proposed by Haws et al. (2014). Apart from its overall reliability, the authors also provide evidence that the scale is not related to socially desirable responding, an issue that is particularly relevant to consumer responses when asked about environmentally friendly attitudes and behaviours (Luchs et al., 2010). The items on this measure cover aspects such as environmental awareness in purchasing decisions and buying habits. Both dependent and additional measures can be seen in Table 14.

6.2.4 Data Collection and Sample Description

The online experiment was designed and hosted on the platform Qualtrics (in a survey like format) while recruitment and distribution were conducted on the crowdsourcing website Amazon Mechanical Turk (MTurk) from 07/07/2021 to 14/07/2021.

The rise of MTurk as a recruitment tool in social sciences initially raised a number of concerns in the academic community; however, research on the demographic representation and reliability of MTurk samples, as well as several successful large scale replication studies utilising them, have addressed these concerns and suggested that the platform can provide reliable data and, in some cases, allow for greater external validity (Thomas & Clifford, 2017). Additionally, Bartneck et al. (2015) indicate that although statistically significant differences do exist between results obtained from participants through MTurk compared to more conventional practices (e.g., on-campus or online recruitment), they are minimal and have no practical implications. The authors also reported that using an external online platform for running a study (as was my case using Qualtrics) had no significant difference from running it within MTurk.

In order to recruit only high-quality MTurk users and ensure the sample's consistency and coherence, the Human Intelligence Task (HIT) posted on the platform was restricted to only users from the United States, with an approval rating of at least 98%, and 5000 or more HITs approved. Therefore, only users who meet those criteria could view the HIT.

I also included additional unique verification codes on Qualtrics to avoid users taking part in the study more than once and a CAPTCHA input to avoid potential bots. Finally, comprehension checks were included in two points during the study, one after participants read the description of the product without a traceability certification and one after they were introduced to it, in the form of a true/false question based on the respective descriptions.

A total of 583 MTurk users participated in the HIT. After discarding incomplete surveys and surveys with invalid verification codes, 518 users were retained, of which two were excluded from the study for having failed both comprehension checks, leading to a final study sample of 516 valid surveys. All demographic details and characteristics of the study's sample can be seen in Table 13.

More than half of the participants (56%) were female, while three-quarters of the sample (77.7%) was below 50 years of age, and most had some level of university education (69.5%). The majority of participants were in some form of employment (82.4%) with the top annual income groups earning between \$50,000 - \$99,999 (38.6%) and \$25,000 - \$49,999 (29.3%).

Table 13.

Demographics and Characteristics of the Study Sample

		N=516 %
Gender	Male	42.8
	Female	56
	Prefer not to say	0.8
	Prefer not to self-describe	0.4
Age	18-29	16.1
	30-39	34.5
	40-49	27.1
	50-59	14.7
	60+	7.6
Education	High School Diploma	19.6
	BSc degree	49.4
	MSc degree	17.8
	PhD	2.3
	Trade/Vocational Scholl	7.2
	Other	3.7
Employment	Employed full time	69.2
	Employed part time	13.2
	Unemployed	7.8
	Student	0.6
	Retired	4.8
	Prefer not to say	1.4
	Other	3.1
Annual Household Income	Less than $25,000	12.6
	$25,000 - $49,999	29.3
	$50,000 - $99,999	38.6
	$100,000 - $200,000	15.3
	More than $200,000	2.3
	Prefer not to say	1.9
Coffee Consumption Frequency	More than 2 cups a day	32.9
	1-2 Cups a day	49
	3-4 Cups a week	6.5
	1-2 Cups a week	6.5
	Less than 1 cup a week	9.8
Are you familiar with sustainable coffee certification schemes?	Yes	34.7
	No	65.3
Have you ever heard of food traceability systems?	Yes	49.4
	No	50.6
Do you know that food traceability systems can prevent with food safety risks?	Yes	48.6
	No	51.4
Do you know that food traceability systems can track food safety problems?	Yes	55.2
	No	44.8
Do you know that food traceability systems can provide information to consumers?	Yes	65.5
	No	34.5

More than 80% of the sample consumed coffee daily; however, around 65% were not familiar with sustainable coffee certifications schemes. Participants were equally split in their awareness around food traceability systems and their ability to prevent food safety risks and track food-related issues, while most (65.5%) were aware that such traceability systems might be able to provide information to consumers.

6.2.5 Data Analysis

All data analysis in this study was conducted using IBM Statistics for macOS, Version 27, while a p-value of $p < 0.05$ was considered significant. Although all measures used in the study were based on existing and validated scales from the literature, factor analysis was again performed to check the structure of each scale before using them for any further analysis and confirm the underlying dimensions the original authors had proposed remain true in the study's sample, followed by reliability analysis for each of those factors.

To test the hypothesis developed, I performed several Analyses of Variance (ANOVA). Specifically, a two-way mixed ANOVA (one within, one between subjects' factor) was used for testing H1 and H2, a series of one-way ANOVAs for H3-H6, and a two-way ANOVAs for H7 and H8, while complex planned contrasts and simple main effects were also utilised, to further explore significant interactions.

6.3 Findings

6.3.1 Factor Analysis

Initially, a principal axis factoring with OBLIMIN rotation was conducted on all items of the measures. All 23 items were scored on several 7-point Likert-type scales (with 1 indicating the least amount alignment and 7 the maximum amount of alignment in all scales). The correlation matrix revealed no multicollinearity concerns while the Kaiser–Meyer–Olkin (KMO) measure confirmed the sampling adequacy of the analysis (KMO=0.92).

A 6-factor solution was yielded, based on Kaiser's criterion of retaining factors with eigenvalues greater than 1, which explained 72.5% of the variance while all items clearly loaded into one factor above the recommended level of 0.40. The extracted communalities ranged from 0.42 to 0.89, with the average communality being 0.73. This solution is also supported by examining the inflection points in the scree plot and is in line with the literature on which the measures were based.

Additionally, a reliability analysis (Cronbach's α) was performed for each factor, with all values being above the recommended level of 0.70. All items in each factor correlate well with the total (no values less than 0.30) and none of the values in the Cronbach's Alpha if Item Deleted analysis are above the overall *a*. Factor loadings and internal reliabilities can be seen in Table 14.

Table 14.

Standardised Factor Loadings and Cronbach's Alpha

Variables	Alpha	Factor Loadings
Willingness to Buy (Pre-test) – 4 Items	0.86	
Would you like to try this product?		-0.71
Would you buy this product if you happen to see it in a store/online?		-0.80
Would you actively seek out this product (in a store/online in order to purchase it)?		-0.68
I would patronise this product/brand.		-0.82
Willingness to Buy (Post-test) – 4 Items	0.88	
Would you like to try this product?		-0.53
Would you buy this product if you happen to see it in a store/online?		-0.66
Would you actively seek out this product (in a store/online in order to purchase it)?		-0.60
I would patronise this product/brand.		-0.73
New Attributes Relative Advantage – 6 Items	0.94	
This product offers advantages that are not offered by competing products.		0.69
This product is, in my eyes, superior to competing products.		0.76
This product solves a problem that I cannot solve with competing products.		0.77
It is likely that the new features will offer advantages to the consumer.		0.88
The new features are likely to add value to the advertised product.		0.85
The new features are likely to perform well.		0.78
Trust – 3 Items	0.91	
I trust:		
That this product can be tracked back (throughout the supply chain).		0.86
The information provided about the production process and origin of this product.		0.87
This product is authentic, which means it has not been tampered with in any way and is what it says it is.		0.80
Environmental Awareness – 6 Items	0.95	
It is important to me that the products I use do not harm the environment.		0.83
I consider the potential environmental impact of my actions when making many of my decisions.		0.94
My purchase habits are affected by my concern for our environment.		0.91
I am concerned about wasting the resources of our planet.		0.78
I would describe myself as environmentally responsible.		0.87
I am willing to be inconvenienced in order to take actions that are more environmentally.		0.88

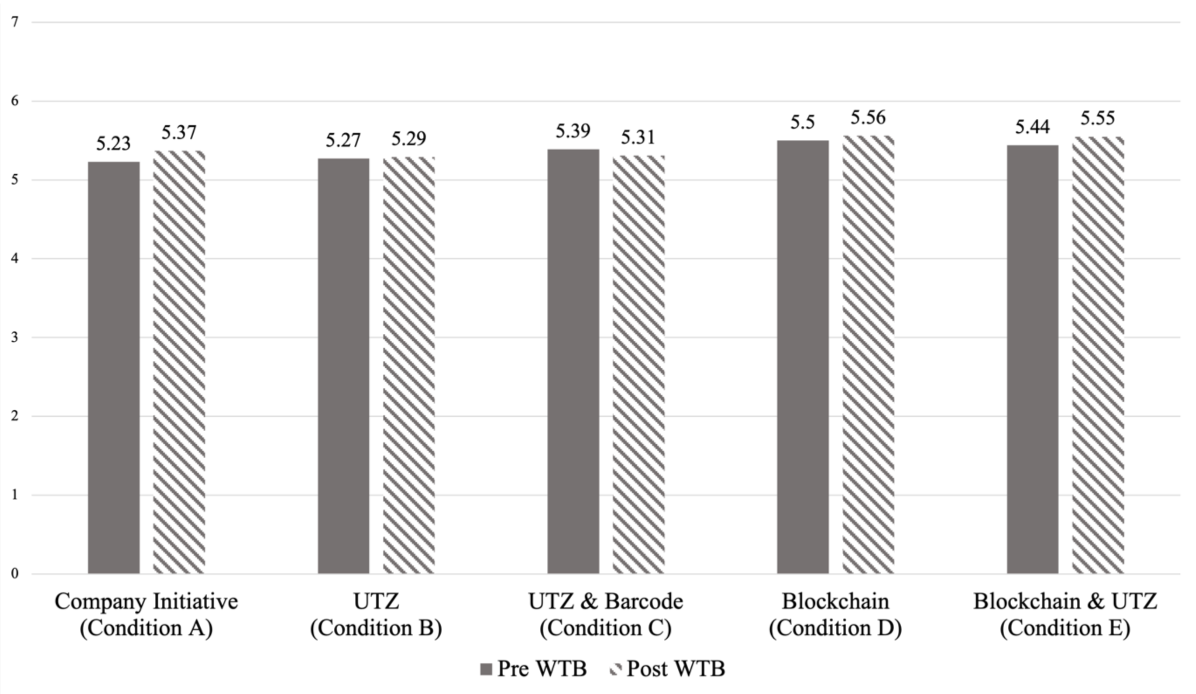
6.3.2 Willingness to Buy (WTB)

To test H1 and H2, a two-way mixed ANOVA (one within, one between subjects' factor) was utilised. Outliers across conditions were Winsorized, a reliable technique for dealing with univariate outliers (Dixon, 1980), by creating a new variable and recoding their scores to the one of the closest non-outlier.

Figure 40 includes participants' WTB before and after introducing them to the traceability system for all experimental conditions. We can see an overall positive WTB for the organic coffee even before the traceability certification was presented, while the two blockchain conditions recorded the highest WTB scores after its introduction ($M_{\text{Blockchain}} = 5.56$, $SD = 1.08$; $M_{\text{Blockchain \& UTZ}} = 5.55$, $SD = 1.25$), followed by the company initiative ($M = 5.37$, $SD = 1.27$) and the two UTZ conditions ($M_{\text{UTZ \& Barcode}} = 5.31$, $SD = 1.46$; $M_{\text{UTZ}} = 5.29$, $SD = 1.22$). Surprisingly, participants in condition C (UTZ & Barcode) reported a slightly lower WTB score after introducing the traceability certification. However, the analysis yielded no significant interaction and main effects between the groups and the two settings, therefore rejecting H1 and H2, a somewhat expected result given the existing but minor differences between the different conditions.

Figure 40.

Mean Scores for Pre-Post WTB

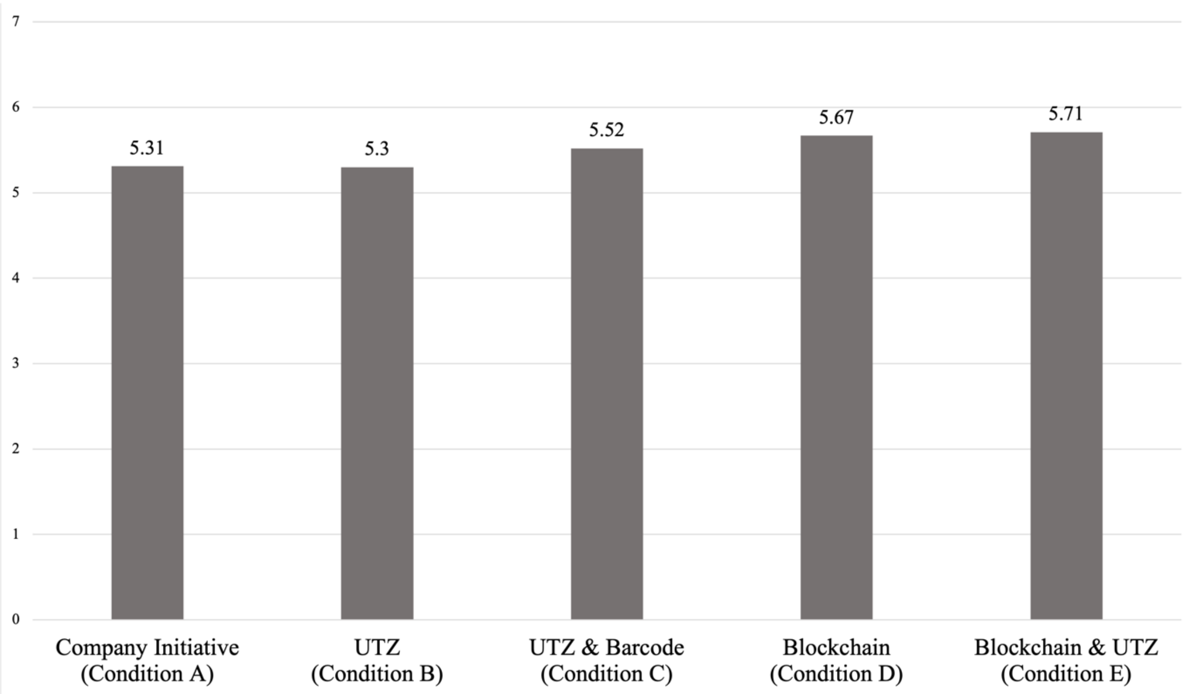


6.3.3 New Attributes Relative Advantage (NARA)

A one-way ANOVA was used to test H3 and H4, while outliers in the conditions were dealt with as before. As with WTB, participants expressed an overall positive evaluation about all traceability certifications with the blockchain conditions recording the highest scores ($M_{\text{Blockchain \& UTZ}}$ = 5.71, *SD* = 1.18; $M_{\text{Blockchain}}$ = 5.67, *SD* = 1.03), followed by the UTZ condition with additional product information (*M* = 5.52, *SD* = 1.09), and the conditions that offered no traceability information ($M_{\text{Company Statement}}$ = 5.31, *SD* = 1.12; M_{UTZ} = 5.30, *SD* = 1.11) (Figure 41). The analysis showed statistically significant differences in NARA between the five conditions F (4, 511) = 3.17, $p < 0.05$, $\eta 2 = 0.024$.

Figure 41.

Mean Scores for NARA



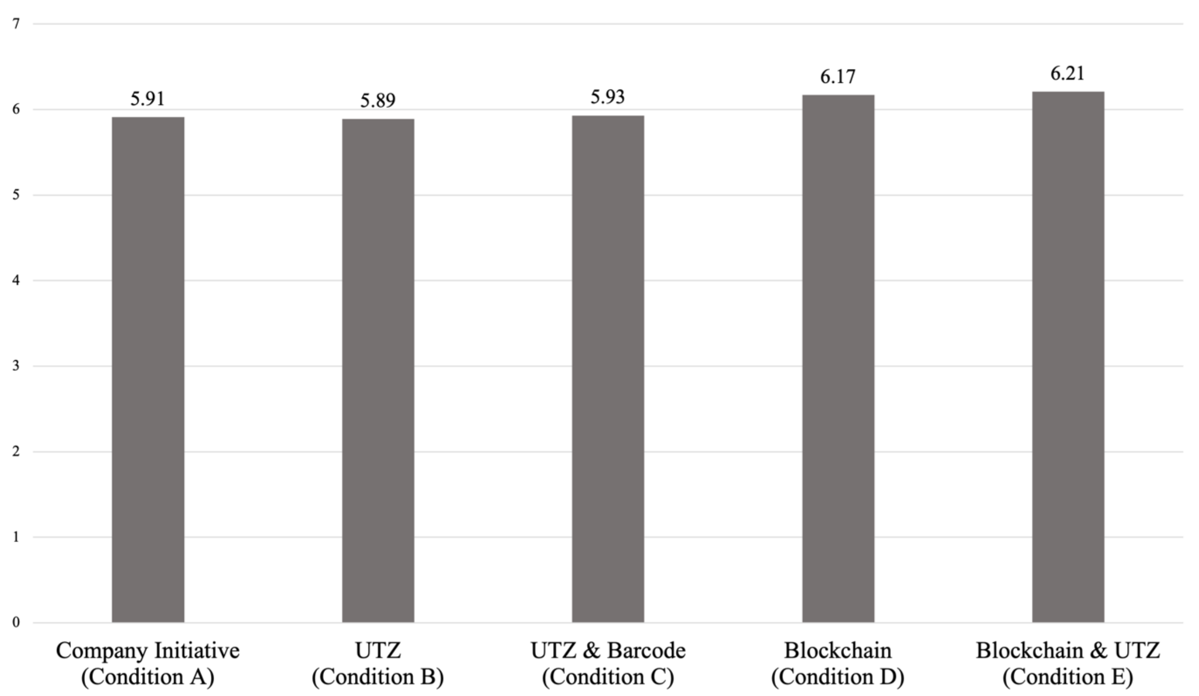
Planned complex contrasts with a Bonferroni adjustment (to control for Type I error) were then used to test the two hypotheses. The planned contrasts revealed that the mean score on NARA for the blockchain conditions (Conditions D and E, *M* = 5.69) was higher compared to the rest of the conditions (*M* = 5.38), a statistically significant difference of 0.32 (95% CI [0.091, 0.538], $p < 0.01$), confirming H3. The second planned contrast also revealed that the mean score on NARA for the conditions that provided additional information on the product (Conditions C, D and E) (*M* = 5.63) was statistically significantly higher compared to the groups that did not (Conditions A and B; $M = 5.31$) by 0.33 (95% CI [0.106, 0.554], $p < 0.01$). Although a small difference amongst relatively high NARA scores in all conditions, this confirms H4.

6.3.4 Trust

A one-way ANOVA was also utilised to explore participants' level of trust towards each traceability certification. As was the case with NARA, all conditions reported high scores in trust. The pattern is also very similar when it comes to the differences between the traceability certifications, with the two blockchain groups recording the highest scores ($M_{\text{Blockchain \& UTZ}} = 6.21$, $SD = 0.87$; $M_{\text{Blockchain}} = 6.17$, $SD = 0.84$), followed by condition C ($M = 5.93$, $SD = 1.04$) and the conditions that provided no additional product information ($M_{\text{Company Statement}} = 5.91$, $SD = 1.04$; $M_{\text{UTZ}} = 5.89$, $SD = 0.95$) (Figure 42). The analysis yielded statistically significant differences in trust between the five certification conditions F (4, 511) = 2.68, $p < 0.05$, $\eta 2 = 0.021$.

Figure 42.

Mean Scores for Trust



To test H5 and H6, planned complex contrasts with a Bonferroni adjustment were used. The first planned contrast compared mean scores on trust for the blockchain products (Condition D and E, $M = 6.19$) with the rest of the conditions (Condition A, B & C, $M = 5.91$) and yielded a statistically significant difference of 0.28 (95% CI [0.086, 0.471], $p < 0.01$) confirming H5. That was also the case for the second planned contrast, which revealed that the mean score on trust for the conditions that provided additional information on the product (Condition C, D and E, $M = 6.10$) was statistically significantly higher compared to the conditions that did not (Conditions A & B, $M = 5.90$) by 0.20 (95% CI [0.006,0.391], $p < 0.05$), confirming H6.

6.3.5 Environmental Awareness

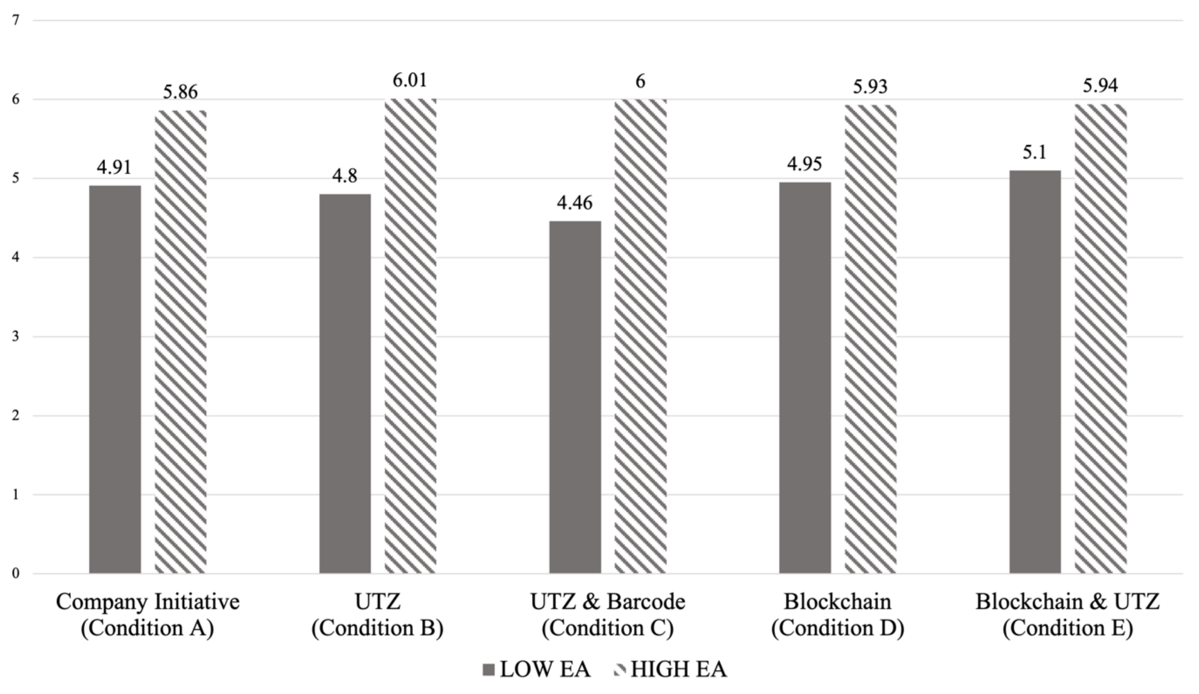
A two-way ANOVA was performed in order to explore the effect of participants' levels of environmental awareness for the different traceability certifications. Before commencing with the analysis, participants were split into low and high environmental awareness groups based on their median split on the environmental awareness measure, a practice well established in social sciences (although not without its critiques as DeCoster et al. (2011) discuss).

Figure 43 shows participants' mean scores for WTB, based on their level of environmental awareness. We can observe that participants with high environmental awareness reported more positive WTB scores across all conditions than participants with low environmental awareness. However, the differences between conditions are minor, with UTZ ($M = 6.01$, $SD = 0.85$) and UTZ & Barcode ($M = 6$, $SD = 1.11$) conditions recording the highest scores, followed by the two blockchain conditions ($M_{\text{Blockchain \& UTZ}} = 5.94$, $SD = 0.96$; $M_{\text{Blockchain}} = 5.93$, $SD = 0.80$) and the condition with the company initiative certification ($M = 5.86$, $SD = 1.13$). At the same time, participants in the low environmental awareness group, reported the highest WTB for the Blockchain conditions ($M_{\text{Blockchain \& UTZ}} = 5.10$, $SD = 1,39$; $M_{\text{Blockchain}} = 4.95$, $SD = 1.36$) followed by the company initiative ($M = 4.91$, $SD = 1.25$), UTZ ($M = 4.80$, $SD = 1.15$) and UTZ & Barcode ($M = 4.46$, $SD = 1.44$). The analysis revealed no significant interaction between environmental awareness and the different certification schemes on WTB scores.

The main effect of the different certification conditions was also not significant, but the main effect of environmental awareness was (F (1, 506) = 116.807, $p < 0.001$, $\eta 2 = 0.19$), indicating that when ignoring the effect of the different certification conditions, the level of participants' environmental awareness significantly affected their WTB. Although not a significant interaction, following up the analysis with pairwise comparisons with a Bonferroni adjustment to explore the simple effects of environmental awareness for each level of the conditions (Faraway (2014) suggests that running simple main effects even when the interaction effect is not statistically significant might be justified) revealed all mean differences to be highly significant ($p < 0.001$).

Figure 43.

Mean Scores for WTB (Environmental Awareness - EA)

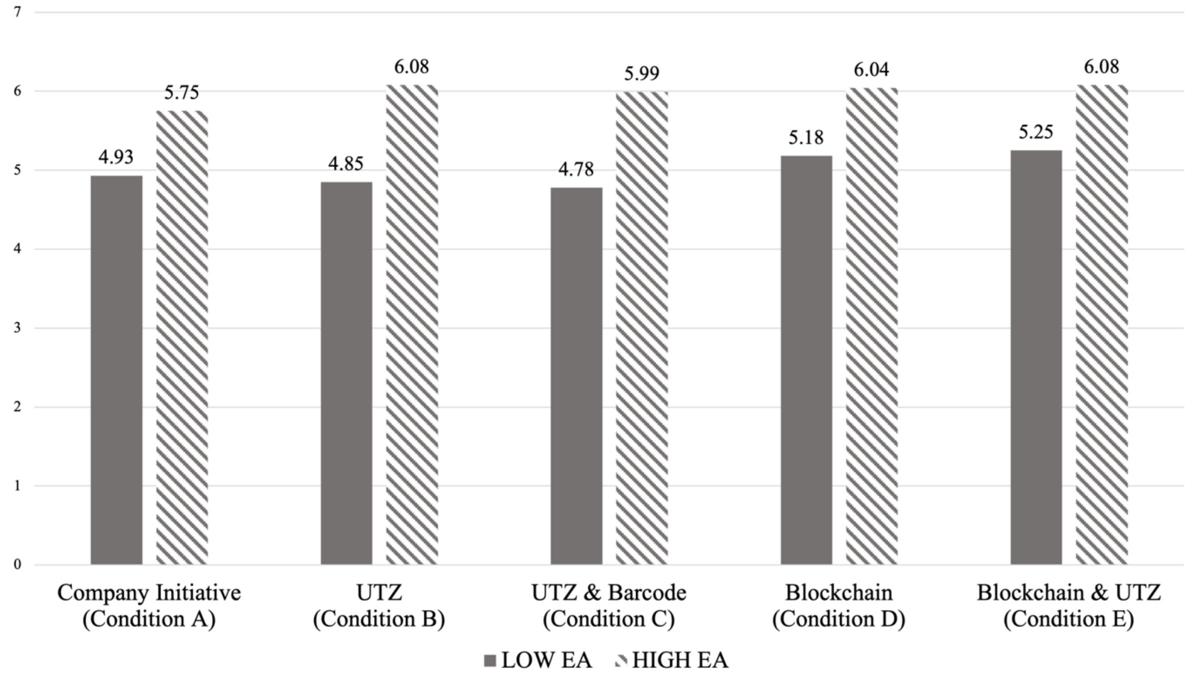


A similar pattern emerged for the NARA variable (Figure 44). Although participants with high environmental awareness reported higher scores regarding the relative advantages provided by the traceability certification compared to participants in the low environmental awareness group, the differences across the different conditions were relatively minute. In the high environmental awareness group, the condition with UTZ certification and with blockchain and UTZ recorded the highest scores ($M = 6.08$, $SD = 0.73$ & $M = 6.08$, $SD = 0.79$ respectively), followed closely by the blockchain condition ($M = 6.04$, $SD = 0.71$), the UTZ and barcode condition ($M = 5.99$, $SD = 0.80$) and the company initiative ($M = 5.75$, $SD = 0.94$). The two blockchain conditions also recorded the highest NARA scores in the low environmental awareness group ($M_{\text{Blockchain \& UTZ}} = 5.25$, $SD = 1.51$; $M_{\text{Blockchain}} = 5.18$, $SD = 1.15$) with the company initiative certification (M = 4.93, SD = 1.09) and the two UTZ certificates (M_{UTZ} =4.85, SD = 0.90; $M_{\text{UTZ \& Barcode}}$ = 4.78, SD = 1.46) ensuing.

As with WTB, the analysis did not yield a significant interaction between environmental awareness and the different certification schemes on NARA, while the main effect of the traceability certification was also not significant. What was significant in this analysis was the main effect of environmental awareness on NARA (F (1, 506) = 112.99, $p < 0.001$, $\eta 2 = 0.97$), indicating its significant effect on participants' NARA. These results were followed by pairwise comparisons with a Bonferroni adjustment, which revealed that all mean differences were highly significant ($p < 0.001$).

Figure 44.

Means Scores for NARA (Environmental Awareness- EA)



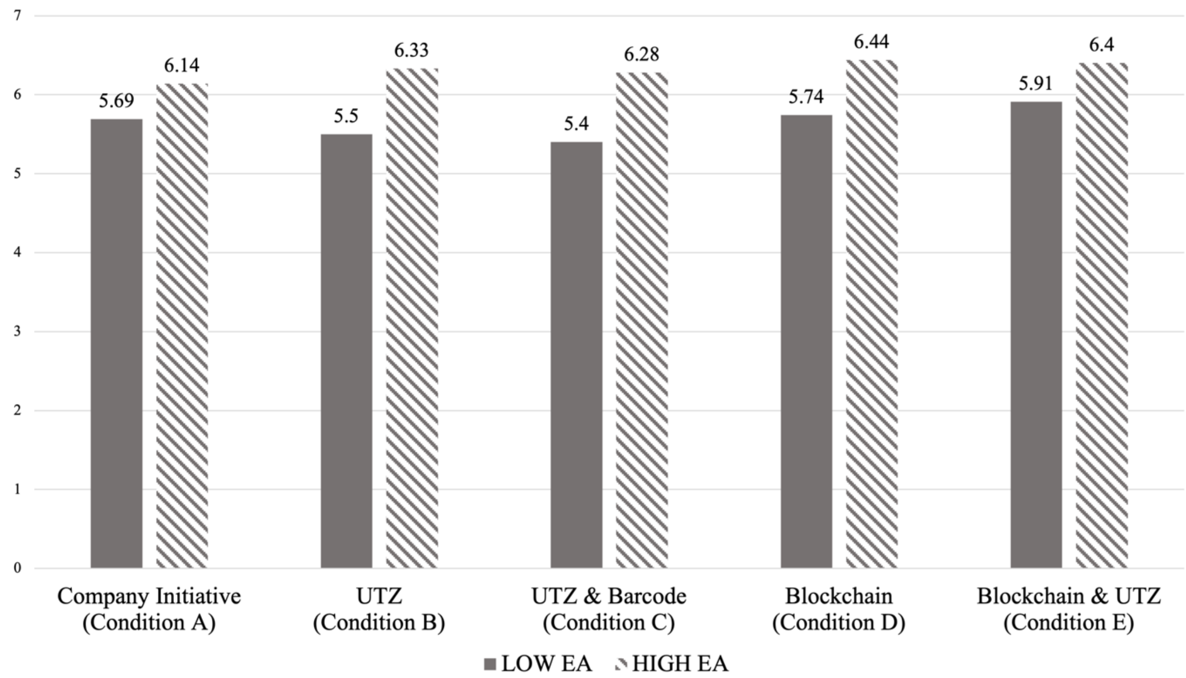
Finally, analogous findings emerged regarding participants' notion of trust towards the different certifications based on their environmental awareness (Figure 45). In contrast with WTB and NARA, where participants with low environmental awareness recorded more neutral scores for all traceability systems than the more positive scores from participants with high environmental awareness, trust scores were high in both groups and for all conditions, although high environmental awareness was associated with higher scores. In the high environmental awareness group, the two blockchain condition were the most trusted ($M_{\text{Blockchain}}$ = 6.44, SD =

0.60; $M_{\text{Blockchain \& UTZ}}$ = 6.40, *SD* = 0.66) follow by the two UTZ groups (M_{UTZ} = 6.33, *SD* = 0.62; $M_{\text{UTZ \& Barcode}}$ = 6.28, *SD* = 0.67) and the company initiative scheme (*M* = 6.14, *SD* = 0.91). In the low environmental awareness group, the two blockchain conditions were again the most trusted ($M_{\text{Blockchain \& UTZ}}$ = 5.91, *SD* = 1.17; $M_{\text{Blockchain}}$ = 5.74, *SD* = 1.09) followed by the company initiative (M = 5.69, SD = 1.02) and the two UTZ conditions (M_{UTZ} = 5.50, *SD* = 1.10; $M_{\text{UTZ \& Barcode}}$ = 5.4, *SD* = 1.36).

As in the previous analysis, the interaction effect and the main effect of the traceability certification were not significant, while the main effect of environmental awareness was (F (1, 506) = 68.501, $p < 0.001$, $\eta 2 = 0.12$), indicating a noteworthy influence on participants trust. In addition, the pairwise comparison with a Bonferroni adjustment that followed was highly significant for all mean differences ($p < 0.001$).

Figure 45.

Means Scores for Trust (Environmental Awareness - EA)



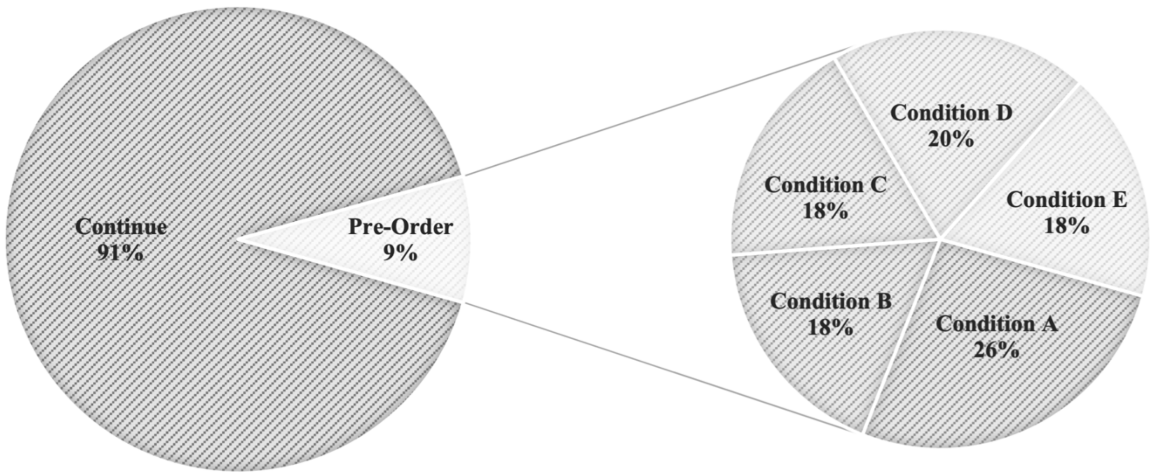
Although participants in the high environmental awareness groups did not record significantly higher scores for the blockchain conditions in WTB, NARA and trust, therefore rejecting H8, they did record significantly higher scores across all conditions compared to participants in the low environmental awareness group, confirming H7.

6.3.6 Intention-Behaviour Gap

At the end of the study, participants were asked a deception question on whether they would like to pre-order the organic coffee product presented to them and offered the option to either place the order or continue with the study (both options led to the same next step of the study). Only 45 participants (9%) choose the pre-order option while the rest opted to continue in the next step (Figure 46). From those that choose to pre-order the organic coffee, 26% was in the company initiative condition, 20% in the blockchain certificate conditions, while the rest were equally split in the remaining three conditions (18% each).

Figure 46.

Percentage of Participants that Pre-Ordered the Organic Coffee Product Based on Experimental Condition



6.4 Discussion

As consumers' interest in sustainability and ethical business practices increased, so did their demand for transparency and accountability from the businesses they support and the products they buy. Since coffee certification schemes and eco-labels are one of the few tools in a company's arsenal for conveying those assurances to customers, their adoption has evolved from simply offering a competitive advantage to now constituting a necessity (Smith, 2018) for engaging with a market that demands increasingly more of them.

Consequently, there is currently a plethora of different coffee certifications schemes in circulation. Research, however, has increasingly questioned their effectiveness and impact (Panhuysen & Pierrot, 2020) as well as their relevance in keeping pace with everchanging and interconnected global supply chain networks (Samper & Quiñones-Ruiz, 2017). In search of new ways to improve and modernise coffee supply chains and adjust to these new market conditions, the industry has turned towards blockchain technologies since they offer a considerably more interconnected and transparent platform while giving access of the system's built-in traceability to the end consumers. This study aimed to explore these new proposed platforms in the coffee industry and investigate how they compare with the existing traceability certification practices in the eyes of the consumer.

The online experiment revealed an overall positive WTB across all different certifications tested with the two blockchain conditions, that also offered additional product information, recording the highest scores, although the differences between conditions were small. The same pattern was true when looking at how participants evaluated the features of each traceability certification (NARA) and the level of trust they had in them. A slightly different image emerged when taking consumer level of environmental awareness into account, with participants in the high environmental awareness group reporting significantly higher scores in all variables of interest than participants in the low environmental awareness group. However, environmental awareness group differences across all certification conditions were more subtle. Interestingly, only a small number of participants chose to pre-order the organic coffee product when given the opportunity at the end of the study.

Although previous research shows that consumers express positive preferences and are willing to pay more for certified coffee, Van Loo's et al. (2015) examination of the literature suggested a considerable heterogeneity in these assessments. This study's findings align with the segment of this literature, which suggests that those preferences are more nuanced and subtle and might depend on the certification under consideration (Howard & Allen, 2010), the profile of the consumer (Basu & Hicks, 2008), and their geographical context (Yokessa & Marette, 2019). The recorded differences in WTB before and after participants were exposed to the traceability certification were relatively small, with the most considerable difference being the company initiative condition (Condition A) followed the condition that combined blockchain with UTZ (E). Surprisingly, participants in the UTZ condition (C) recorded ever so slightly lower WTB scores for the organic coffee product after exposure to the traceability certification.

An additional view for the slim differences in all experimental conditions between the coffee product with and without traceability certification could be found in past modelling from Carlson (2009), who suggested that since certification schemes cause minor increases in the price of coffee, consumers are willing only to pay a small premium for certified coffee products compared to ones with no certification. What is also interesting is that although Basu & Hicks (2008) reported that consumers' WTP changes depending on the information provided about a scheme's benefits, that was not the case in this study where the additional system descriptions did not seem to influence participants' WTB.

The same pattern of positive but insignificant variances emerged when comparing the different certifications used in the study, with the two blockchain conditions recording the highest WTB, something that is in alignment with the research in Chapter 5, that indicated a possible consumer inclination towards blockchain traceable organic coffee. Surprisingly the company initiative certification (A) recorded a marginally higher WTB score than the UTZ condition (B) and even the UTZ condition that offered additional information (C). Although research on comparing consumer preferences for multiple coffee certification labels is limited, Basu et al. (2018) reported relatively small differences in consumers' WTP when examining a variety of well-known coffee certifications. That was also the case in Van Loo's et al. (2015) study, with the differences in the price premium participants were willing to pay for different organic coffee certifications being small, and for some types of certifications, insignificant.

The findings from this study are not in line with initial expectations that the blockchain conditions (H1) and the conditions that provide additional product information (H2) will elicit higher WTB scores than the rest of the certifications. As Yokessa & Marette (2019) discussed, the proliferation and complexity of current certifications and eco-labels has hindered consumers' capacity to differentiate between them. That is evident in this study, with participants recording overall positive scores for all conditions, but with minimal differences in WTB between them, despite the descriptions provided in all conditions and the additional traceability information offered in the blockchain coffee products. Further research will be essential in clarifying those findings and exploring whether the provision of additional product information supported by a blockchain platform is an influential factor for consumers' WTB.

One might argue that the current state of organic coffee certifications and the evident equation of all the different schemes in the eyes of the consumer might also be a result of what

(Schwartz, 2004) terms the paradox of choice, suggesting that as the number of available options increases, consumers' capacity to reliably realise what the best option is, decreases. Although each participant in this study was only presented with one traceability certification, it is possible that their past exposure to the multitude of different labels, as well as their limited knowledge and awareness about what they mean, can create a certain level of confusion about their purpose, resulting in attributing the same amount of positive WTB regardless of the issuing body, the processes it follows or the amount of additional product information it provides. Past research has suggested that greater choice should be offered to consumers in product domains that they feel less knowledgeable about (Hadar & Sood, 2014); however, when it comes to organic coffee certifications, it seems like the myriad of labels offered during the past decades have hindered consumers' ability to objectively assess their value.

Participants in this study also recorded positive scores across all conditions in their evaluation of the features of the traceability certifications, with the blockchain conditions recording the highest scores, followed by the UTZ condition that provided additional information (C). As discussed earlier, the mere existence of a traceability certification logo can have a positive influence on consumers (Johe & Bhullar, 2016), while the provision of additional traceability information not only enhances their confidence and food safety decision making (Lam et al., 2020) but is also in line with consumer survey data that call for greater transparency and informative product labelling (EIT, 2020; Hahn-Petersen, 2018).

That was also the case in this study, with both hypotheses regarding higher NARA scores on the blockchain conditions (H3) and the conditions that provide additional product information (H4) emerging as significant. At the same time, these significant differences are not of great magnitude. Although a possible justification might be the low cognition level of consumers regarding traceability (Hansstein, 2014; Martinez & Epelbaum, 2011), this study provided participants with additional system descriptions in all conditions, making this reasoning less likely. Therefore, a more plausible explanation for the minor differences between the groups might lie in the confusion caused by the current overflow of certifications in the market (Glasbergen, 2018), leading, again, to the equation of the certificates used in the study in participants' minds.

Although significant and positive, these minute NARA differences for the blockchain and the additional product information conditions are somewhat surprising, particularly considering the plurality of features a blockchain-based supply chain traceability system can offer, as previously discussed. Compared to the current organic coffee traceability schemes in the market, the bulk of which correspond to the ones used in this study, a blockchain-based system can not only provide a more transparent and reliable overview of supply chain processes (Kshetri, 2018; Wang et al., 2019) but could also allow access to that information to the end consumer (Boukis, 2020), both options not currently available from in-house and third-party certifications. It is also important to highlight that in certain platforms, blockchain systems allow for a more direct connection between consumers and producers (such as the UCC Coffee (2020) "*Thank My Farmer*" initiative), a significant advantage over any of the existing schemes and one that allows consumers to convey they support and appreciation towards local farmers. Future research should examine this initial positive inclination for the features offered by blockchain traceability and the provision of additional product information and potentially expand to other products and certifications to further establish its effect and magnitude.

As we saw earlier in the literature review, regaining consumer trust is a fundamental reason for companies pursuing new traceability solutions since research has revealed that such systems can play a crucial role in rebuilding consumer confidence (Lam et al., 2020). Participants in the study reported high levels of trust across all conditions and, as with NARA, the two blockchain-supported products recorded significantly higher scores (H5), as did the products that offered additional product information (H6). These differences align with initial expectations that blockchain-supported product traceability could increase trustworthiness (Tschorsch & Scheuermann, 2016) and with research from (Nie & Luo, 2019) that reported trust as a significant predictor of purchasing intentions for such products.

Even though these differences are not as prominent as the literature would suggest and the high trust scores across all conditions might indicate the same "equation effect" as with NARA, they do point towards a potential higher confidence for blockchain-supported products, in which the notion of trust is removed from solely the logo and is diversified to include the additional product information. It is worth pointing out that previous research did not find trust to be a significant predictor of consumer purchasing intentions for blockchain traceable coffee; however, this finding is more intricate and should be interpreted with caution since the degree to which trust is a significant predictor of purchasing intentions for products that provide additional traceability information might be product, culture, and country specific, as was demonstrated in Chapter 5.

Finally, this study also explored participants' preferences for the various traceability certifications based on their level of environmental awareness. The aforementioned rise of green consumer and their demand for production transparency (K. White et al., 2019), in combination with the positive purchasing effects connected with higher environmental consciousness (K. H. Lee et al., 2015), led me to hypothesis an overall positive attitude from participants with higher environmental awareness towards all certifications, in general (H7), and the blockchain conditions (H8), in particular. Indeed, past research has pointed out that the degree to which a certification/eco-label is efficient depends, to a large extent, on the overall consumer sensitivity towards the environment and the concept of sustainability, given that their purchasing preferences for green attributes can dictate how goods are produced (Yokessa & Marette, 2019). This point can be further supported by eye-tracking studies in product eco-labelling, which suggests top-down attention where higher motivation and engagement with food sustainability led subjects to look for such information on the product (Pieters & Wedel, 2004).

The results of this study also support these notions, with participants in the high environmental awareness group reporting more positive scores for all variables of interest within each certification condition used in the study, compared to the low environmental awareness group. The differences between the various traceability certifications for the high environmental awareness group were non-existing, except for condition A that recorded slightly lower scores on WTB, NARA and trust, suggesting a lesser preference from participants to the company initiative certification compared to the more established UTZ and the blockchain conditions that provide additional information. This pattern was replicated in the low environmental awareness group, but with condition C recording moderately lower scores, potentially indicating that the infographic format of the additional information provided by UTZ certification did not have the expected effect.

Although participants with high EA did record positive scores across all three variables of interest, the fact that the differences between the certifications used were so minute might indicate a couple of noteworthy points regarding industry practices and consumers' true attitudes toward green credentials. First, in terms of the industry, one might argue that the greenwashing practices of companies, such as adopting certification schemes for the sole purpose of portraying a "green" and eco-friendly image (Goodman, 2010), are rather successful in that even environmentally aware consumers will have a positive valuation of a certification regardless of the processes it follows, the feature it offers and its overall transparency. Second, consumers might overstate their preferences for green credentials or, to put it more fairly, might not be that willing to go out of their way and conduct any background checking to ensure that a company follows the practices and processes it claims it does. Although not the focus of this study, these points are of particular interest not just for companies utilising or considering a blockchain-based system but for the industry as a whole, and it would be interesting for future research to further examine both the direct effects of greenwashing practices as well as consumers' real intentions around green/sustainability credentials.

There are two main limitations in this study. The first one concerns measuring WTB and, therefore, participants' purchasing intentions which, as the deception question indicated, do not always align with actual purchasing decisions; only 9% of the sample chose to pre-order the coffee product. There are, of course, other valid reasons for that low percentage, one of which might be that the study did not mention the price of the product, a pivotal factor in consumer decision making even for "green consumers" with positive environmental and sustainability attitudes (Mortimer, 2020). Although the gap between intentions and purchasing behaviour regarding green products is documented in the literature (K. White et al., 2019), further research involving actual purchasing data or potentially field experiments in stores might shed further light on this pattern.

The second limitation revolves around the study's design since it precludes my ability to delve deeper into discovering the precise reasons for the minor differences across the experimental conditions, some of which are in contrast with the literature derived expectations. Although the results indicate an overall positive attitude towards blockchain traceability and additional product information, future research should examine the potential effect older and more established coffee certifications might have on consumer decision making. For instance, the planned interactive workshop discussed in Chapter 3 (which was eventually cancelled due to COVID) could provide such complementary insights.

A third potential limitation might also lie in the fact that this study, as well as the previous one, examined a blockchain-based traceability system for a single-ingredient product, that is, organic coffee. As has been discussed by Champion et al. (2018), multi-component supply chains are far more complex and compartmentalised, potentially creating a set of different conditions for businesses and requirements from consumers. This point will be further deliberated in the next chapter when discussing the overall limitations of this thesis.

6.5 Conclusions

The intricacies and complexities of coffee supply chains, in combination with growing consumer demand for transparent business and manufacturing practices, have led businesses, governments, and academics alike to increase experimentation with blockchain technologies in order to improve production traceability and rebuild consumer confidence.

This study contributes towards that effort by providing insights on consumer preferences for blockchain traceable coffee in an experimental setting with multiple other traceability certifications. To the best of my knowledge, this is the first piece of research to examine such an area, which diverts from the plethora of other research angles and sheds some initial light on the perspective of and implications for the end consumer. Although the coffee products supported by blockchain certifications recorded the highest trust and attribute evaluation scores, the differences with the rest of the certifications were relatively small, including participants' WTB. The same pattern emerged when examining the data through the lens of environmental awareness, although there were apparent differences between the high and low groups.

On a research level, this study provides new evidence on consumer decision making for multiple types of coffee certification, an already understudied research area (Basu et al., 2018), while the addition of blockchain traceability offers a much-needed perspective in the literature around consumer's perceptions and preference for this technology and how it compares with the existing market schemes. Additionally, it further supports past research both around the importance of consumers' level of knowledge and interest in the environment and sustainability and how it affects their purchasing intentions and valuation of product features, as well as in the existence of a potential discrepancy between purchasing intentions and actual purchasing behaviour.

On a practical level, this research suggests that although consumers reported overall positive attitudes and intentions towards blockchain traceability certifications, there is still room for improvement in differentiating the technology's proposition compared to the existing certifications in the market. Given that blockchain allows for a more holistic view of all supply chain processes, companies should focus on increasing consumers' awareness and interest in the technology through marketing campaigns built around the concept of traceability and with a particular focus on what the additional product information means for them. Additionally, government agencies and authorities could apply more pressure to business, as they have already successfully done after the numerous food scandals and nudge them towards more accountable and traceable supply chains by requiring better production and general supply chain information, not only for compliance proposes but for dissemination to the end customers.

Ultimately, the success of blockchain in overcoming the shortcomings current coffee traceability certifications face and adding value to the entire chain would depend not only on businesses investing in the development of the technology itself but on establishing a solid understanding of the consumers they are selling to, increase their awareness and interest around the benefits it offers, and find ways to differentiate its proposition from the rest of the market. In the next chapter, I am going to further discuss these final points as well as the overall findings of this PhD and its implications.

7 General Discussion

Although many scholars have argued that globalisation was initiated during Europe's Age of Discovery (Hopkins, 2002), it was not until the Information Age that the concept went into what some historians characterised as overdrive (National Geographic Society, 2019), a state that greatly contributed to and is largely responsible for today's interconnected global economy. These conditions, however, have created the need to integrate the objectives and goals of multiple and oftentimes conflicting supply chain network partners into an organisation's decision making and management processes. Inevitably, there has been increasing interest over the past decades in utilising e-business systems and platforms to facilitate this challenge (Vakharia, 2002).

In the eyes of many, the emergence of blockchain technologies in the late 2000s offered a suitable platform that could function as the testbed for creating a more transparent, collaborative, and efficient value chain, from raw material production all the way to the end consumer. That prospect led numerous businesses and organisations to experiment with the technology, ranging from established multinational corporations and government initiatives exploring ways to update and modernise their operations to start-ups and SMEs looking to innovate and establish new SCM models and platforms. For all that effort and investment, however, blockchain adoption and growth in SCM (if not in other areas of application) has reached a certain plateau, the overcoming of which could prove a make-or-break point for the technology.

In the opening chapters of this thesis, I argued that a possible reason for this gridlock could lie in the absence of empirical research (being academic or otherwise) that focuses on the social, collaborative and governance aspects of the technology as well as the lack of the consumer perspective and preferences for products that are supported by blockchain traceability systems. This argument led to the formulation of the two research questions this PhD seeks to address (Table 3). The first explored which aspects and characteristics of blockchain applications in SCM are most relevant to industry decision-makers and whether their organisation needs to adopt and implement the technology. The second investigated how consumers perceive blockchain applications for coffee traceability, established the influential factors determining their intentions to purchase products that utilise them, and compared them with existing traceability certifications in the market.

The overall aim of this holistic approach was to fill the empirical and knowledge gap in this understudied research area as well as provide companies and decision-makers with insights that could aid with the initial design of such systems and the successful implementation and broader adoption of the technology. Through this process, my research also reaffirmed the validity of an established research model in consumer purchasing behaviour, that is the TPB, and, more importantly, contributed towards its expansion by providing evidence for variables that can increase its predictive power. It also proposed an effective presentation format for product traceability information that could function as a blueprint for future designs.

In the next section of this general discussion chapter, I will rearticulate the main findings of the three studies conducted (7.1), followed by their implications both at the industry (7.2) as well as the consumer level (7.3). Next the importance of the right policy and regulatory environment will be highlighted (7.4), followed by the research limitations of this PhD (7.5).

7.1 Blockchain for Supply Chain Traceability – Industry Considerations and Consumer Preferences

The first study of this PhD explored the views and perspectives of industry professionals on blockchain applications in SCM, in general, and four specific aspects of the technology, in particular, and whether it provides the right solutions for their business problems. There was a "vested interest" in the technology and an expectation that it will play a significant role for organisations moving forward, with an expected ROI in the next half-decade. Uses cases around supply chain transparency and traceability, provenance, and enhanced network collaboration and information sharing attracted the most attention of the participant sectors included in this study. All four technology aspects examined (trust, traceability, regulation, relationships) were favourably viewed, as was participation in industry consortia with the goal of accelerating learning and adoption.

Two areas of particular interest for industry professionals emerged from my research. The first concerns the absence of industry and geography-specific regulatory frameworks around which companies and organisation can build their systems. The second revolves around questions of who gets to participate within a network and what policies and safeguards are in place that could protect participants' privacy and enable collaboration in a trusted and reliable manner. That tension was evident in the results of the decision-making flowchart used in this study, which suggested that two blockchain implementations could provide appropriate solutions for just above 40% of participants. At the same time, however, there was one blockchain solution for each of the five participant sectors, highlighting the need for and importance of a case-by-case approach in the decision-making process.

In the second study, the attention was turned to the consumer perspective on using blockchain technologies for product traceability in the coffee industry. This industry was chosen because it offers one of the most suitable use cases for research in terms of supply chain complexities, established traceability certification bodies that are not keeping up with modern demands, the existence of several market-ready and/or in use blockchain applications as well as a strong consumer interest around the environmental and sustainable credentials of the product. Using an extended version of the TPB, this study revealed that positive attitudes, PBC and environmental protections were accountable for 46% of the variance in participants purchasing intentions for blockchain traceable coffee. Additionally, participants were confident in obtaining and understanding the additional traceability information presented to them in the app format and a certitude around the product's place of origin. It is worth mentioning that when asked if and how much more they are willing to pay for the version of the coffee that offered blockchain traceability information, 75% of participants reported a willingness to pay more, with the price premium ranging from an additional 5% - 30% of the conventional certification coffee price.

The final study of this work built on the previous research and attempted to establish consumer preferences for blockchain supported traceability coffee products, compared to other traceability certifications, in a more realistic market setting. The results of the online experiment conducted on the MTurk platform among 516 participants revealed that although WTB for the two blockchain certifications tested was positive, the differences with the rest of the certification systems were minor. That was also the case regarding trust, and system feature evaluations (NARA), where the two blockchain conditions with the additional product information recorded the highest scores but by small margins from the rest. Interestingly, when the participant's level of environmental awareness was taken into account, apparent differences emerged in all three variables between the low and high environmental awareness groups, although the differences between the traceability certifications tested remained, once again, subtle. Nevertheless, when given the opportunity to place a pre-order for the coffee product they were presented with, only a small number of participants chose to do so, with pre-orders being almost equally split between the five traceability certifications tested.

7.2 Industry Considerations

Various academics and industry analysts have identified several dilemmas and points of conflict blockchain applications in SCM might face on the road to broader adoption. And although the vast majority of them are not supported by empirical data, they seem to emanate from past experience with similar emerging and disruptive technologies. For instance, Higginson et al. (2019) suggested that in order for the technology to move forward in the industry lifecycle, it needs to have a clearly defined problem, a valid business case with a realistic ROI, as well as medium to long term commitment and continuous support towards their project.

At the same time, Balzarova (2021) focused on more fundamental aspects of blockchain applications in SCM and suggested that the level of decentralisation and matters around the robust security of the system, as well as the degree those two affect scalability, need to be initially addressed before moving forward with any further implementation. Finally, and in the same line of thinking, Kumar et al. (2020) discuss that questions around the design and validation of smart contracts, considerations of data management, and the impact of channel configuration on privacy and visibility are all critical challenges in the implementation process of blockchain applications in SCM. Although all these reported challenges and open issues around the technology also emerged in the views and opinions of industry processionals expressed in the first study of this PhD and, as the discussion in Chapter 4 pointed out, are in alignment with parallel findings in the academic literature, this PhD further revealed three key points.

The first important takeaway for industry professionals is that before any technical discussions and system implementations commence, their respective organisations need to address the power dynamics within their blockchain ecosystem and define incentives and opportunities that will allow network participants to get involved with the governance of the technology. That is, create a clear and concise plan of who will participate in the system and define the nature of their involvement. For all the “trustless” interactions this technology can support, participants in this PhD’s first study clearly expressed a tension around aspects of trust and privacy and the need for clear guidelines and frameworks around blockchain implementations.

To a certain extent, therefore, and since collaboration through information sharing and transparency are fundamental properties of the technology, one might argue that a general shift in the industry’s approach, attitudes and philosophy might also be required, in which cooperation and shared responsibility between businesses in the development of standardised procedures and protocols is central. This shift in business philosophy might give rise to the cooperation paradox, which suggests that not many companies and organisations are willing to put all the effort and resources into developing a platform that could benefit the entire industry (Higginson et al., 2019). Nevertheless, participants in the study also expressed positive sentiments towards consortium participation, which implies that such a shift might not be far away, especially with the proper regulatory guarantees in place.

Another important point emerging from answering this PhD’s first research question is that blockchain technologies do not offer a one fits all solution, a suggestion made by many commentators, especially in the early days of the technology. It was clear throughout the study that the different sectors represented in the sample reported different attitudes toward different blockchain characteristics. For example, while participants from the logistic sector reported the highest scores regarding the relationship management aspects of the technology, they also reported the lowest scores in traceability and regulation, a pattern followed by participants in the energy sector with relatively low scores on all four aspects. On the other hand, participants from the aviation and food sector reported high scores across the board, the former expressing the most positive views on trust and regulation and the latter having the highest score on traceability.

A final point of interest is that the regulation around blockchain applications in SCM will play a crucial role in the uptake of the technology. The initial assumption that blockchain has fallen into an institutional void, which hinders its transition through Moore’s chasm (2014), seems to be supported in the views of industry participants. Although most expressed a sceptical stance around the positive impact of increased government legislation in SCM, at the same time, they reported that the absence of industry and jurisdiction-specific legislation, as well as clear guidance on information reporting for compliance purposes, are significant concerns within their blockchain projects. Several government departments and agencies have developed reports and whitepapers for utilising blockchain and DLT technologies in SCM (Champion et al., 2018; Christie, 2018; Department for Business, Energy & Industrial Strategy & Office for Product Safety & Standards, 2020; Food Standards Agency, 2019; Hong Kong Applied Science and Technology Research Institute (ASTRI), 2016; Staples et al., 2017; Walport, 2016) in an attempt to boost experimentation with the technology, and this research suggests that it is possibly time for a more active engagement and the development of a specific policy and regulatory frameworks that will give companies the certainty to make the next step.

7.3 Consumer Preferences

If research around the views and perspectives of industry professionals on blockchain features that go beyond the technical aspects of the technology is understudied in the literature, the attitudes and preferences of the end consumer for products that utilise them for traceability purposes are practically absent. Since one of the main propositions of implementing blockchain in SCM is to enhance transparency and traceability across the value chain, research from the consumer end can provide critical insights into the development direction of blockchain applications that also meets increasing demands for sustainable business practices and transparency.

Both studies conducted on consumer preferences for blockchain traceable coffee as part of this PhD suggested positive attitudes from consumers, particularly around the additional product information the technology offered. Participants in the second study also expressed confidence in obtaining and understanding that information by scanning the QR code on the product. At the same time, the results from the online experiment revealed that the two products supported by blockchain traceability recorded the most favourable scores in feature evaluation. Although some researchers have suggested that the provision of additional information from labelling schemes might be insufficient and confuse consumers (Grolleau et al., 2016), that did not seem to be the case in both studies conducted.

What did emerge from my research, and was also discussed in Chapter 6, is the potential presence of an "equation effect", in which the plethora of existing traceability certifications seems to have equated their value and purpose in the eyes of the consumer, who might consider them "all the same". Indeed, one could assume that consumer preferences around traceability certifications and labels might fall within what (Cialdini, 2021) describes as mental shortcuts (i.e., heuristics), behaviours that are triggered by specific stimuli and lead to the same outcome almost every time. For instance, expensive = good is a trigger which implies that paying a higher premium for a product will result in higher quality. The same pattern can occur with traceability certifications where a label for fair trade, green practices, and ethical sourcing automatically triggers responses of safety and quality in the mind of consumers, irrespectively of who issues it and what it entails, resulting in the mindset that seeing a label can automatically be an indicator of these qualities.

At this stage, and with a particular focus on the coffee industry examined in the two studies, companies and organisations that utilise blockchain traceability certification need to take active steps towards differentiating their offer from the rest of the market. The importance of product differentiation for the modem coffee consumer has been highlighted in the literature (Teles & Behrens, 2020), especially on grounds of quality, flavour, and origin. Therefore, and since such consumers have a more holistic demand around ethical and sustainable business practices, as well as transparency and accountability, organisations and companies utilising blockchain applications could focus their marketing and branding efforts on the additional information they provide and the reliability and trustworthiness these systems offer.

Another point of interest in consumer views on blockchain traceability is the role of trust. Although participants in the second study (Chapter 5) reported a positive belief in the product information presented to them, trust did not emerge as a significant predictor of purchasing intentions. At the same time, participants in the online experiment (Chapter 6) reported positive scores on trust for all certification labels, with the two blockchain conditions recording significantly higher scores. I discussed in Chapter 5 how past research had reported conflicting results regarding the role of trust as a predictor of purchasing intentions of traceable products within the TPB and how the significance of this variable for the coffee industry might be product and country specific. A recent review of consumer trust in the food value chain across five European countries (Macready et al., 2020) further enhances that point by not only reporting different levels of consumer trust and confidence for different supply chain actors but that these differences might be a product of cultural specificities, diverse institutional frameworks and other geopolitical variables. Although my research suggests that a blockchain-based traceability system could positively impact consumer trust and confidence, the magnitude of the effect these variables might have on that trust is still not apparent. Since I was not able to further explore and define that relationship due to the inherent limitations of a PhD, it will be necessary for future research to provide clarity and clearly define any potential moderation and/or mediation effects.

A final takeaway for this part of my research is the role of consumer awareness and understanding around traceability systems and their importance if ensuring the consistency and quality of products. Although consumers' perceived level of environmental protections offered by a certification system can be a significant predictor of purchasing intention for blockchain traceable coffee, and participants with high environmental awareness recorded higher scores on all variables of interest, the overall understanding of product traceability, in general, and blockchain, in particular, as well as what kind of assurances these systems can offer seems to be absent for half of the sample in both studies conducted. Although these traceability systems are complex and can be challenging to explain to the average consumer, Gao et al. (2016) report that even individuals involved in blockchain projects sometimes do not fully comprehend the technology), a more collaborative industry effort to convey their benefits will have a positive impact in their preferences for products that utilise them. Here, the role of governments and regulators might also be of use in "nudging" companies and consumers in that direction.

7.4 The Challenges and Opportunities of Regulating Blockchain in SCM

At this stage of the thesis, it is becoming clear that governments and institutions could play a more active role in the overall adoption and growth of blockchain technology in supply chain management and product traceability both for the industry as well as the end consumer. As initially hypothesized, the technical development of blockchain systems might have reached a sufficient level, but the social, cooperative and consumer aspect is creating a series of challenges that hinder broader adoption and implementation. A possible solution to address both might lie, once again, at the hand of the regulator.

I have already discussed in Chapter 2 the impact government regulation can have in shaping, transforming and, in some cases, redesigning the entire supply chain operations of companies and organisations, with the most prominent example being EU General Food Regulation (EC, No 178/2002) and the ensuing prerequisites for “one step back” - “one step forward” traceability systems (Charlier & Valceschini, 2008). That practice, of course, goes well beyond food traceability. The radical plan of the UK Government, for example, to bring forward its net-zero targets and ban the sale of new petrol and diesel by 2030 has significant ramifications not just for car companies that need to radically adjust their manufacturing processes but for their entire supply chain networks (Pirie et al., 2020). At the same time, such strict regulations around CO_2 emissions and a more sustainable future have also forced companies to explore more cooperative models and future-proof their business, with many co-developing new electric car platforms to reduce innovation costs (a recent example being Honda co-developing a new electric vehicle platform with General Motors (Lienert, 2022)) or even merge into new multinational corporations in order to keep their average emission below the regulatory threshold (the recent merger between Fiat Chrysler Automobiles and PSA Group into Stellantis serves as such an example (Winton, 2021)).

I have also touched on some of the existing efforts around blockchain legislation, both in terms of cryptocurrencies and digital currency exchanges (Hammond & Ehret, 2022), as well as the early endeavours for more industry-wide governance and enforceability frameworks, particularly around blockchain-secured signatures and smart contracts (Casper et al., 2021) and using the technology to maintain company records (Isham III, 2019). Blockchain, however, still largely remains a terra incognita area for governments and regulators. Angela Welsh, for example, has highlighted issues with tracking down and adequately defining the language used within the array of different blockchain systems and how such language and be translated into legislative terms (Walch, 2017), as well as how to legally treat the different parties participating in a blockchain network, particularly in public and permissionless systems (Walch, 2018).

In the same line of thinking, De Filippi & Wright (2018) have extensively discussed the ability of blockchain technologies to create transnational, resilient, and automated structures for services and value exchange, often circumventing existing legislation, and create their own system of rules and private regulatory frameworks, in what they have termed as lex cryptographica. These newly formed systems, of course, create additional concerns for states wishing to shape and influence their development and even have the potential, if left unsupervised, to replace key societal functions. In light of these challenges, the authors suggest that regulatory efforts around blockchain technologies should focus on two main aspects. First, on controlling areas where the technology interacts with existing regulatory entities such as individuals and networks that develop and support the technology. Second, on creating frameworks for regulating the incentive schemes that underlie blockchain systems and for facilitating the standards of existing networks and consortia.

Examining the existing governance structures and frameworks within blockchain might also provide valuable insights and particular areas of focus on appropriately regulating the technology. For example, Beck et al. (2018) suggested a blockchain economy governance framework based on decision rights, accountability, and incentives. Building upon their work, Hofman et al. (2021) proposed an expanded model that covers a multitude of aspects, such as establishing values and use cases, identifying actors and stakeholders, accounting for temporality and monitoring change over time, clear guidelines of data, records, and protocols, compliance with geographically diverse laws and regulations, and internal power structures.

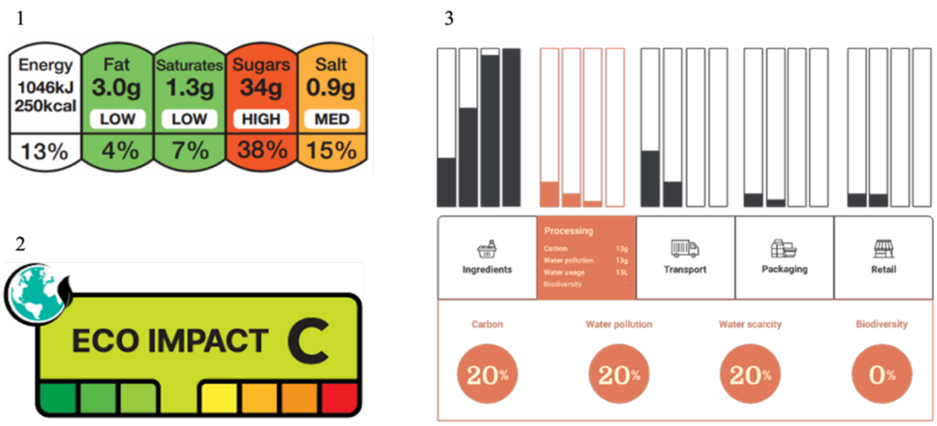
Another point to keep in mind, and which was also discussed earlier in this thesis, is that the intricacies in designing policy and regulatory frameworks for emerging technologies, often lead to what Hajer (2003) described as an institutional void. Here, past experience can also provide useful, if not actionable, insights on how blockchain applications in supply chain management and product traceability might overcome it. As Goyal et al. (2021) explain, it was policy entrepreneurship that framed technological change as an issue for data privacy and, by exploiting a policy window, managed to bring in the General Data Protection Act, which harmonised user data protection and privacy laws across the EU. This opportunity to dictate policy also seems to be in place for blockchain applications in SCM. The last decade brought a stream of regulatory efforts around supply chain transparency (see Chapter 2.3) while there is an evident interest both from government and extremal bodies in the use of the technology in further facilitating that effort. At the same time, there is a significant amount of investment and experimentation in the broader market, which eagerly awaits (as the first study of this PhD demonstrated) for more clarity to establish the direction and future development of its platforms. If we also consider the increased consumer demand for greater business transparency and product provenance, one could argue that the current environment provides a fertile ground for such regulatory efforts.

This regulatory framework can take many possible directions, but, at its core, it needs to primarily address the industries' concerns around issues of privacy and resolution settlement, harmonisation with industry-specific global standards, as well as clear guidelines on compliance procedures. Since blockchain allow flexibility in who gets to access the system as well as a certain degree of process automation, an existing (or new) regulatory body can set its specific criteria and requirements within a platform and allow for real-time monitoring while maintaining access to the entire ledger and past transactions for compliance purposes. It will also be important for any regulatory initiatives not to constrain the types of blockchain used but allow room for companies to select the version that best suits their needs.

This framework could also extend toward empowering consumers and raising their awareness regarding product traceability. Such an approach can be based on the existing practice of utilising a traffic light system label to convey aspects such as nutritional value (Food Standards Agency, 2016) (No 1 in Figure 47). The validity of this practice has also been tested in the literature(Cecchini & Warin, 2016; Roberto et al., 2012). For instance, Sonnenberg et al. (2013) reported that such labels not only helped participants to consider their health when purchasing a product but "nudged" them toward selecting the healthier choice. The same idea is applied by Foundation Earth and their Eco Impact certification (Foundation Earth, 2020) that, apart from providing a similar traffic light label (No 2 in Figure 47) on the product, allows consumers to further explore the product's environmental impact in various metrics and aspects of production (No 3 in Figure 47).

Figure 47.

Traffic Light System Labels



Note. 1. Food Standards Agency Nutrition Label (Food Standards Agency, 2016); 2. - 3. Earth Foundation Eco Impact Label and Information Dashboard (Foundation Earth, 2020).

In an integrated blockchain-based traceability system, where regulators have access and can determine both the quality and quantity of an organisation's supply chain data, a similar label could be used to convey the level of traceability information this product provides and hence, how transparent a company supply chain is. In the case of coffee, for example, along with the QR code, consumers will be able to easily understand the level of supply chain transparency the product offers by simply looking at the label while also having easy access to more detailed traceability information on their phones. Existing certifications and traceability schemes could also be included in this process, as was demonstrated in Chapter 6**.**

7.5 PhD Research Limitations

Although research limitations for each study conducted as part of this PhD were discussed at the end of their respective chapters, this section provides the opportunity to consider them within the general context of this PhD and the two research questions it addressed. Apart from the relatively small sample size in the industry survey (Chapter 4) and not being able to conduct semi-structured interviews that would have allowed me to delve deeper into professionals' views on the technology, the absence of coffee companies from that part of my research poses a potential limitation. Given the fact that coffee was used as the case to examine consumer preferences for blockchain traceable products, the inclusion of companies from that sector might have provided a more suitable alignment between the two research questions. Unfortunately, although participation invitations were sent to all known coffee companies that utilise the blockchain in their SCM, no surveys were returned from the sector.

One has to consider, of course, that the pool of enterprises utilising blockchain traceability systems for their products is limited and expanding the research pool to the coffee industry, in general, would not provide participants with the know-how around implementing the technology in their business. At the same time, and since there is still uncertainty around blockchain, the broader view of applications in SCM from various industries allowed for insights that would not have been possible by focusing only on one industry. Nevertheless, the inclusion of companies from the coffee sector, especially ones that have released market-ready applications, would be a significant next step and could provide a more complete picture of this specific industry.

At the same time, the decision to use organic coffee as the product of focus for the studies described in Chapters 5 and 6 has created another set of considerations. Although coffee supply chains are definitely complex, particularly around the number of production steps and processes and the coordination of an extensive global network (Bradley & Botchway, 2018; Miatton & Amado, 2020), coffee still remains a single ingredient product. As discussed earlier, most food supply chains are considerably more intricate, with a wide variety of ingredients sourced from several different countries and following diverse standards and processes (Champion et al., 2018). These multi-compound value chains create a fresh set of challenges for businesses wishing to utilise blockchain technologies for their management in terms of system scalability and inclusion of the various parties involved for each component, reliably monitoring compliance and quality of raw materials, as well as simplifying and clearly conveying that complex information to the end customer. Future research examining the use of blockchain for tracking such products will unveil significant insights to further solidify the technology's value proposition in SCM for the food sector.

An additional limitation for both studies (Chapters 5 & 6) on consumer perceptions and preferences around blockchain traceable coffee was evaluating participants purchasing intentions and not their actual behaviour. Although I tried to circumvent this limitation in the online experiment by creating a market-like environment and employing a deception question, this tactic worked only to a certain extent. Therefore, field experiments in stores, and potentially with an additional sample that is not just regular coffee drinkers but, what one might call, coffee connoisseurs, would help further establish their purchasing behaviour and might also reveal new insights that could not be derived from the average coffee consumer.

A final point around this PhD's limitations is the disruption the COVID-19 pandemic had on the research design and choices made throughout this work. I already discussed in Chapter 3 some of the opportunities created by the pandemic, which were to the benefit of both my personal development as a researcher as well as the academic robustness of my work. However, although this thesis successfully addresses both research questions and provides a plethora of original academic contributions and practical insights, the semi-structured industry interviews, along with the interactive workshop and field experiment planned, would have addressed some of this works limitations, provided additional clarity on the influence of some of the variables examined and further strengthened the current findings and overall argument.

8 Conclusions

Several digital evangelists were quick to characterise the rise of blockchain and distributed ledger technologies at the dawn of the past decade as a panacea for most business problems, including longstanding supply chain and operation management challenges. These prophecies were promptly followed by various enterprises and organisations, which, although adopting a much more cautious approach, saw these technologies as having the potential to transform and redefine their sector. More than a decade later, however, these expectations have ground to a halt, creating the need to re-examine blockchain's proposition for SCM and product traceability and establish essential aspects of the technology that have been understudied in the literature and can facilitate its transition in the industry lifecycle.

The research conducted in this PhD suggests that the first step in order to cut through the hype around blockchain and distributed ledger technologies for SCM applications is not to see them as the revolution that will radically change the structure of the world, as some of the evangelists claimed, but rather, as an evolution of existing institutions and an improvement on the ways businesses cooperate and exchange value. As the internet and the proliferation of information improved and "democratised" a number of settings around us, so these technologies could provide part of the underlying infrastructure for a more transparent and cooperative environment, benefiting the entire value chain.

Andreas Antonopoulos (2016), one of the most prominent (and reasonable) voices in the blockchain community, makes a valid point about the effects of exponential innovation on the existing social structures. He discussed that in an increasingly interconnected world where borders become less and less relevant when it comes to business and innovation, our existing hierarchical structures are failing to scale in order to meet market needs. We now use networks and services that span across the entire world and are embedded in a global system of finance, logistics and labour. The past decade has proved that under certain circumstances, decentralisation can be an efficient way to coordinate resources and production as well as optimise decision-making. Since in such an interconnected world, almost every good consumed is linked to a journey of people, places and materials and given the increased demand for business transparency and sustainable production processes, such benefits can also "trickle-down" to the end consumer.

With the objective of closing the identified research gap in the literature and provide industries with usable insights on how to further their projects, this PhD provided answers to two main questions. The first established the most relevant aspects and characteristics of blockchain applications in SCM for industry decision-makers and which factors will determine if they actually need to implement the technology for their business case. The second examined consumer perceptions around blockchain applications for coffee traceability, determined the influential factors that can predict purchasing intentions for products that utilise them, and established how they compare with existing traceability certifications in the market.

The findings addressing the industry side of the blockchain conundrum in SCM moved beyond the current literature and suggested that clear and concise collaborative and governance frameworks, along with a general shift in the industry's approach to collaboration and cooperation, will be critical for the successful implementation of the technology. At the same time, these solutions need to be examined and adjusted based on the particularities of each sector. This research also provided empirical evidence for the usefulness of decision-making flowcharts regarding the implementation of blockchain technologies and suggested that they could be a complementary tool in an organisation's arsenal. The importance of these findings does not solely lie in fulfilling the knowledge gap in the literature but in providing enterprises and professionals with key areas of consideration for deciding whether blockchain makes sense for their case and, if it does, ways to successfully approach its implementation.

At the same time, the two studies in the consumer segment of this PhD provided, to the best of my knowledge, the very first pieces of evidence on consumer preference for blockchain traceable coffee. The positive views around the technology, in combination with the palatability of the app format the additional product information was presented, led to an increased WTP a price premium for blockchain traceable coffee. When placed, however, in a market like condition and compared with other available coffee traceability certifications, a possible equation effect emerged which suggests not only the importance of product differentiation for companies, with a particular focus on environmental guarantees the system offers, but the need to increase consumer awareness around the concept of traceability and its benefits. Apart from the importance of these findings for companies and the design of their traceability applications, it is also imperative to highlight the research contribution of both these studies, one in expanding the TPB and providing evidence for a new variable that can significantly increase the model's predictive power and one in providing a new line of research by including blockchain systems in the already understudied area of consumer decision making and preferences for multiple types of coffee certification.

It would constitute an omission, before closing this work, to give the impression that it is all sunlit uplands for blockchain applications in SCM moving forward. As the joint report from the UK Department for Business, Energy & Industrial Strategy and the Office for Product Safety & Standards (2020) concludes, the cost of implementing the technology, be it hardware and software related or passing these overheads to the end consumer, in combination with traditionally risk-averse industries, such as coffee, and inherit data integrity risks associated with the technology could prove significant challenges for broader market adoption. The latter consideration seems to have attracted a substantial amount of scepticism in the literature, with Balzarova et al. (2021) characterising the points where the technology encounters the human factor, either in terms of inaccurate data entries or discrepancies between physical word products and their digital representation, as blockchain's Achilles' heel.

Although one can argue that blockchain is only the messenger and the system does not bear responsibility for its contents, the utilisation of IoT devices and various other environment monitoring sensors (as discussed in Chapter 2.3), the affordability of mobile digital communications that readily allows system access to remote areas of the supply chain often located in the developing world, along with the possible cooperation with existing certification standards to ensure quality and consistency of raw materials could circumvent some of these issues and achieve the overall goal of a more open, transparent and sustainable value chain that is, in the long run, beneficial for all.

While blockchain managed to create a craze among business executives and institutions, and even resurface long-held ideas of total decentralisation and cyberanarchism, it seems like, when it comes to SCM applications of the technology, these elements take a more moderate form, where questions of who is who and who does what as well as how the entire value chain interacts with the system need to be addressed. As this research concluded, a possible compromise for the technology might lie in the role of governments and institutions who can provide the regulatory environment for the technologies to grow and for consumers to get more involved in the concepts behind them. Although I have discussed various directions for future research in each induvial research chapter as well as in the general discussion, I believe that focusing on this latter point of policy development and the establishment of working frameworks will be of great importance for the immediate future of the technology. Maybe, after all, my initial suggestion that blockchain diverges from Kaiserfledt's (2006) neo-classical approach, which proposes that markets facilitate the appropriate conditions for technological innovation, might be correct, and, in this case, it is the technopolitical context that is highly influential for its successful development and adoption.

Ultimately, and as my PhD journey comes to its end, the main takeaway from this thesis is not just successfully answering the research questions formulated and generating new knowledge for the field, and therefore fulfilling, to a certain extent, the university's expected doctoral outcomes. Throughout these years of working on all the various projects that constituted my research, I realised that the much more significant potential of this technology, and of similar technologies and innovations, lies in the ideas of collaboration, openness, transparency and accountability and the appeal they have at this moment in time not only to consumers and industries but to all of us.

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Appendix 1: Study 1 Additional Materials

Research Ethics Approval

Ethics Review of your Research Project

Stella Fuller <lgzsaf@exmail.nottingham.ac.uk>
Wed 08/05/2019 12:23
To: Symeon Dionysis <psxsd5@exmail.nottingham.ac.uk>
Cc: Davide Pero <lqzdp1@exmail.nottingham.ac.uk>

Dear Symeon

Project Title: Distributed Ledger Technologies:The Socioeconomic Implications of Blockchain Based Trust Across Multiple Economic Sectors

I am writing to confirm a favourable ethical opinion for the above research on the basis of the documentation submitted. This opinion was given on 29th April 2019.
The following conditions apply to this favourable opinion:

1. The research must follow the protocol agreed and any changes will require prior NUBS REC approval.
2. When the research project has been completed you must submit a report stating that is has been completed using the agreed protocol. This can be done via e-mail.

For further information about the School's Research Ethics Committee or approval process, please contact the School Research Ethics Officer, [mailto:Davide%20Pero%20%3clqzdp1@exmail.nottingham.ac.uk%3e]Davide Pero or +44 (0)115 84 67763.
Good luck with your research

Stella

Stella Fuller
Senior Administrator - Research

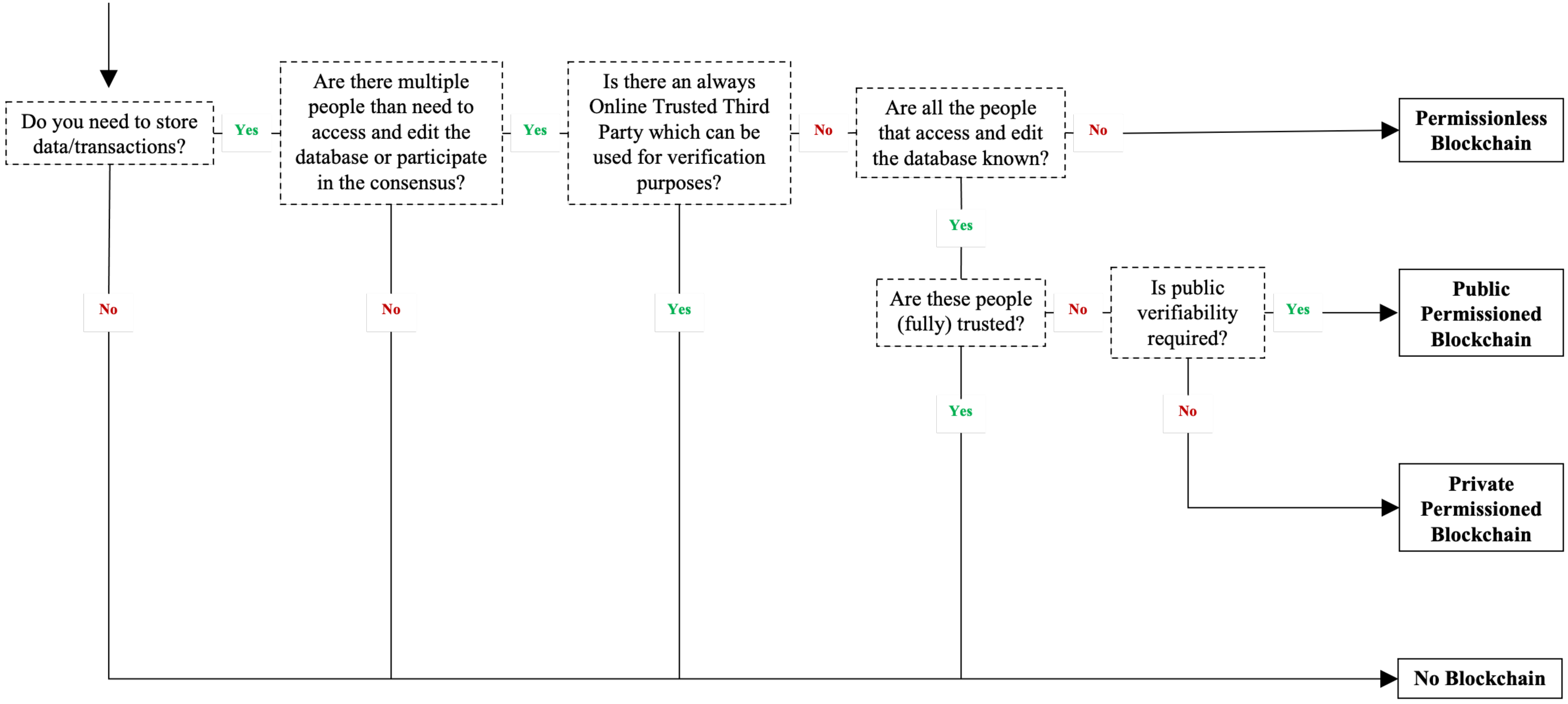
Nottingham University Business School/Faculty of Social Sciences
University of Nottingham
Room A01, Business School North Building
Jubilee Campus
Wollaton Road
Nottingham, NG8 1BB

Working hours: Monday – Friday 09:15 to 17:30

+44 (0) 115 8467581 I stella.fuller@nottingham.ac.uk

Enquiries: Li-Research-Support@nottingham.ac.uk

Blockchain Decision Making Flowchart (Modified Version) (Figure 11)



Appendix 2: Study 2 Additional Materials

Research Ethics Approval (Cancelled Workshop)

University of Nottingham
UK | CHINA | MALAYSIA

Faculty of Social Sciences
Nottingham University Business School
University of Nottingham
Jubilee Campus
Nottingham
NG8 1BB

7 February 2020

To whom it may concern,

RE:	**Project Title:**	Distributed Ledger Technologies: The Socioeconomic Implications of Blockchain Based Trust in Food Supply Chains
	Chief Investigator:	Symeon Dionysis
	Co-Investigators:	Thomas Chesney and Derek McAuley

NUBS REC reference: 201819053

I am writing as chair of the Nottingham University Business School Research Ethics Committee (NUBS REC) to confirm a favourable ethical opinion for the above research on the basis of the documentation submitted below. This opinion was given on 3 February 2020.

The School REC operates according to the University of Nottingham's *Code of Research Conduct and Research Ethics, and the Economic and Social Research Council (ESRC) Framework for Research Ethics.*

The documents reviewed and approved are:

- NUBS REC Ethics Review Checklist
- Participant Information Sheet – Generic
- Research Participant Privacy Notice

The following conditions apply to this favourable opinion:

1. Management permission ("R&D approval") must be obtained from each host organisation prior to the start of the study at the site concerned.
2. The research must follow the protocol agreed and any changes will require prior NUBS REC approval.
3. The appropriate NUBS REC documentation must be completed at the end of the research project.

For further information about the School's Research Ethics Committee or approval process, please contact the Research Ethics Officer, Davide Pero at davide.pero@nottingham.ac.uk or +44 (0)115 84 67766.

Yours faithfully,

Dr Amanda Crompton
Chair of Nottingham University Business School Research Ethics Committee

Research Ethics Approval (Revised for TPB Questionnaire)

Ethics Review Application No.: 201819053 - Distributed Ledger Technologies: The Socioeconomic Implications of Blockchain Based Trust in Food Supply Chains - Symeon Dionysis

LI-Research-Support <LI-Research-Support@exmail.nottingham.ac.uk>
Fri 07/02/2020 18:42
To: Symeon Dionysis <psxsd5@exmail.nottingham.ac.uk>
Cc: Davide Pero <lqzdp1@exmail.nottingham.ac.uk>; Thomas Chesney <liztc@exmail.nottingham.ac.uk>; Derek McAuley <pszdrm@exmail.nottingham.ac.uk>

1 attachments (349 KB)
NUBS Ethics Approval Confirmation Letter_Symeon Dionysis.pdf;

Dear Symeon

Ethics Review Application No.: 201819053 - Distributed Ledger Technologies: The Socioeconomic Implications of Blockchain Based Trust in Food Supply Chains - Symeon Dionysis

I am writing to confirm a favourable ethical opinion for the above research on the basis of the revised documentation submitted. This opinion was given on 3 February 2020.

A signed confirmation letter is also attached for your information.

The following conditions apply to this favourable opinion:
1. The research must follow the protocol agreed and any changes will require prior NUBS REC approval.
2. The appropriate NUBS REC documentation must be completed at the end of the research project.

For further information about the School's Research Ethics Committee or approval process, please contact the Research Ethics Officer, Davide Pero at davide.pero@nottingham.ac.uk or by telephone on: +44 (0)115 846 7766.

Good luck with your research!

Best wishes,

Debbie

NUBS Research Support Team Manager
University of Nottingham
Business School North, Room B12
Jubilee Campus
Nottingham, NG8 1BB

+44 (0) 115 84 66183 | NUBS-research-support@nottingham.ac.uk
Please note that due to staffing absences and a high volume of work requests, there may be a delay in responding to, and actioning your email. Thanks for your understanding.

Organic Coffee Visual Aids & Certification Description (Blockchain) (Figure 34)

Blockchain technologies were introduced in 2008 as the supporting infrastructure of Bicton. Although the use of the technology was initially limited to digital currencies, throughout the years, researchers and companies realised the potential of blockchain and started utilising it to address the long-standing issues of transparency and traceability in supply chains.

In its simplest form, blockchain is a distributed ledger, a database containing information, shared across a network of computers. A set of such databases can create a block which is then cryptographically sealed. Everyone in the network has access to that ledger (hence, the word distributed). When someone wants to update the ledger, a new block is created containing the updated datasets as well as all the information from the previous blocks. In time, this forms a chain of blocks that are distributed across the network and cannot be tampered, since it will alter the chain and it will be immediately spotted. Digital signatures and cryptography also verify the validity and authenticity of an update request, making sure it's genuine.

Several companies have been experimenting with utilising blockchain technologies to enhance transparency and traceability in coffee products, both for farmers and supply chain actors as well as for the consumer. After farmers harvest the coffee cherries, all data related to their crops are uploaded to the blockchain. Relevant data will also be uploaded during the processing of those cherries. The processed beans will then be shipped to various markets, with all shipping information being tracked in the system. During the roasting process information, including grades and blends, will be updated.

The final packed product will be equipped QR code allowing consumers to check themselves their coffee's journey. During all points of the coffee's journey, from farmer to consumer, all information is kept in a single immutable system instead of a cumbersome and complex paper trail process. It is the same system that consumers are getting partial access to when scanning the QR code, allowing for reliable information regarding the journey of their coffee, even, in some cases, allowing them to directly thank or support the farmers (see the image below for an example of the scanning process works).

Overall, Blockchain Certification not only enhances transparency and traceability in the coffee supply chain, but it also carries those benefits to the end consumers by allowing them to access part of the system in ways that traditional certification, like UTZ, does not. However, Blockchain certification doesn't provide a framework of good practices and standards that UTZ does.

Organic Coffee Visual Aids & Certification Description (UTZ) (Figure 34)

UTZ (originally UTZ Kapeh, meaning "good coffee" in the Guatemalan Mayan language of Quiché) is a non-profit organisation founded in 2002 by Nick Bocklandt and Ward de Groote with the goal to bring sustainable coffee certification for consumers to the global market as well as promote sustainable farming practices. UTZ is the largest program for sustainable coffee and cocoa farming in the world, while they also provide services for tea and hazelnuts. In 2018 UTZ merged with the Rainforest Alliance, and they are currently working on a joint certification program.

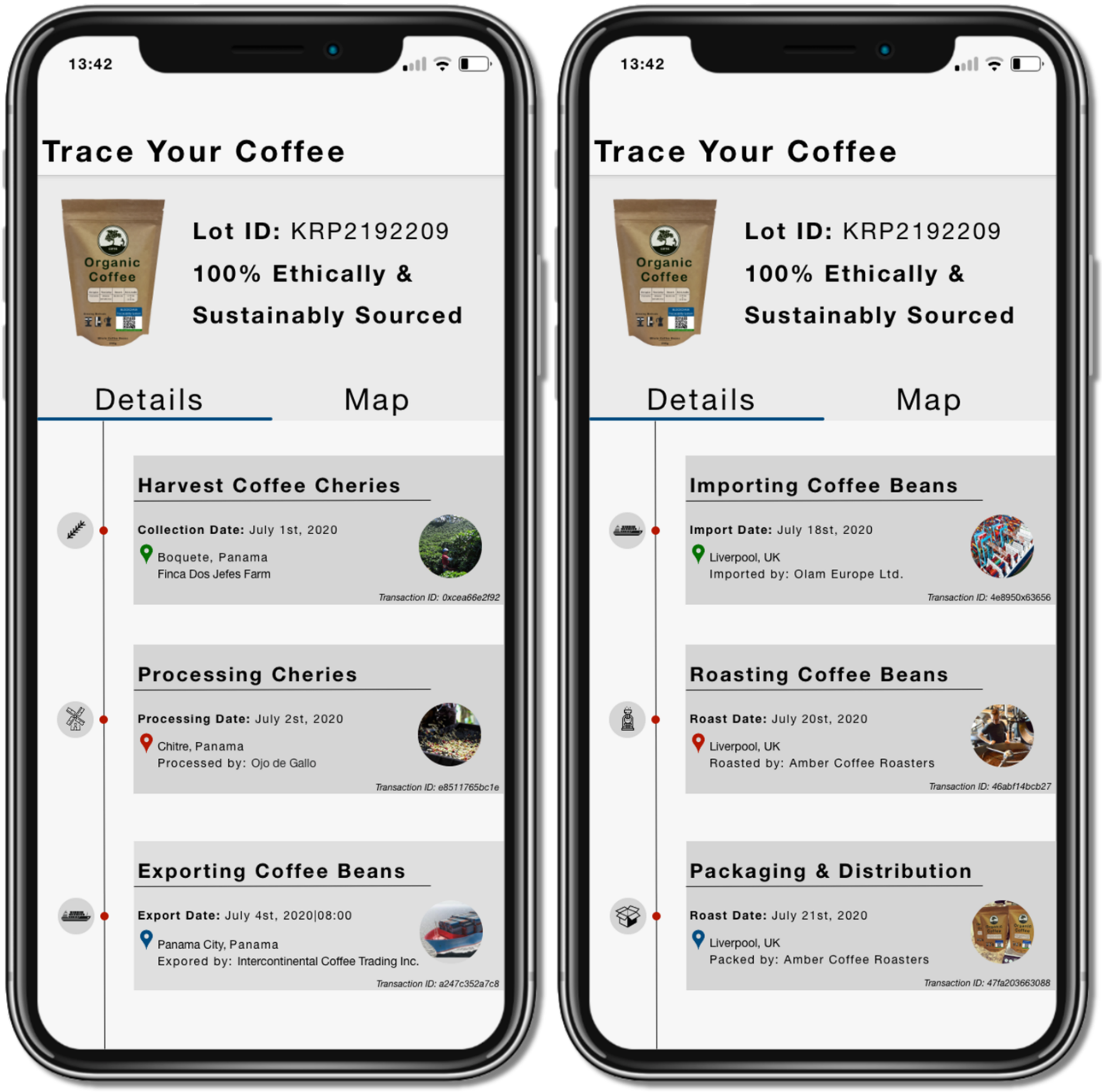
UTZ sets quality standards both for farmers as well as for supply chain actors. These standards are developed in collaboration with external bodies, NGOs and all actors throughout the supply chain. UTZ standards are divided into two sections. The first is the code of conduct, targeted toward farmers, and covers aspects of management, farming practices, working conditions and environmental protections. The second section of the standards is the chain of custody, targeted toward supply chain actors, and addresses administrative practice and product traceability.

After finalising these standards, UTZ trains what they call capacity builders. These agents will train the farmers on the organisation's code of conduct and sustainable farming practices. At the same time, UTZ trains external certification bodies, which will be responsible for auditing both farmers against the code of contact as well as supply chain actors against the chain of custody.

Traceability of products, referring to the ability to identify and verify the components and chronology of events in all steps through a product's journey, is one of the most significant aspects of UTZ certification. Using the MultiTrace Platform, UTZ is tracking their product's journey from farmers to processing and from transportation to manufacturing to the end retailer, so consumers can be confident that the UTZ labelled product they are buying comes from certified sources. This traceability system still requires a lot of paperwork and record-keeping, as well as several different parties to facilitate it. Additionally,
Access to The MultiTrace platform is restricted to producers and companies, with consumers not being able to check and verify a product's journey themselves but instead having to trust UTZ claims.

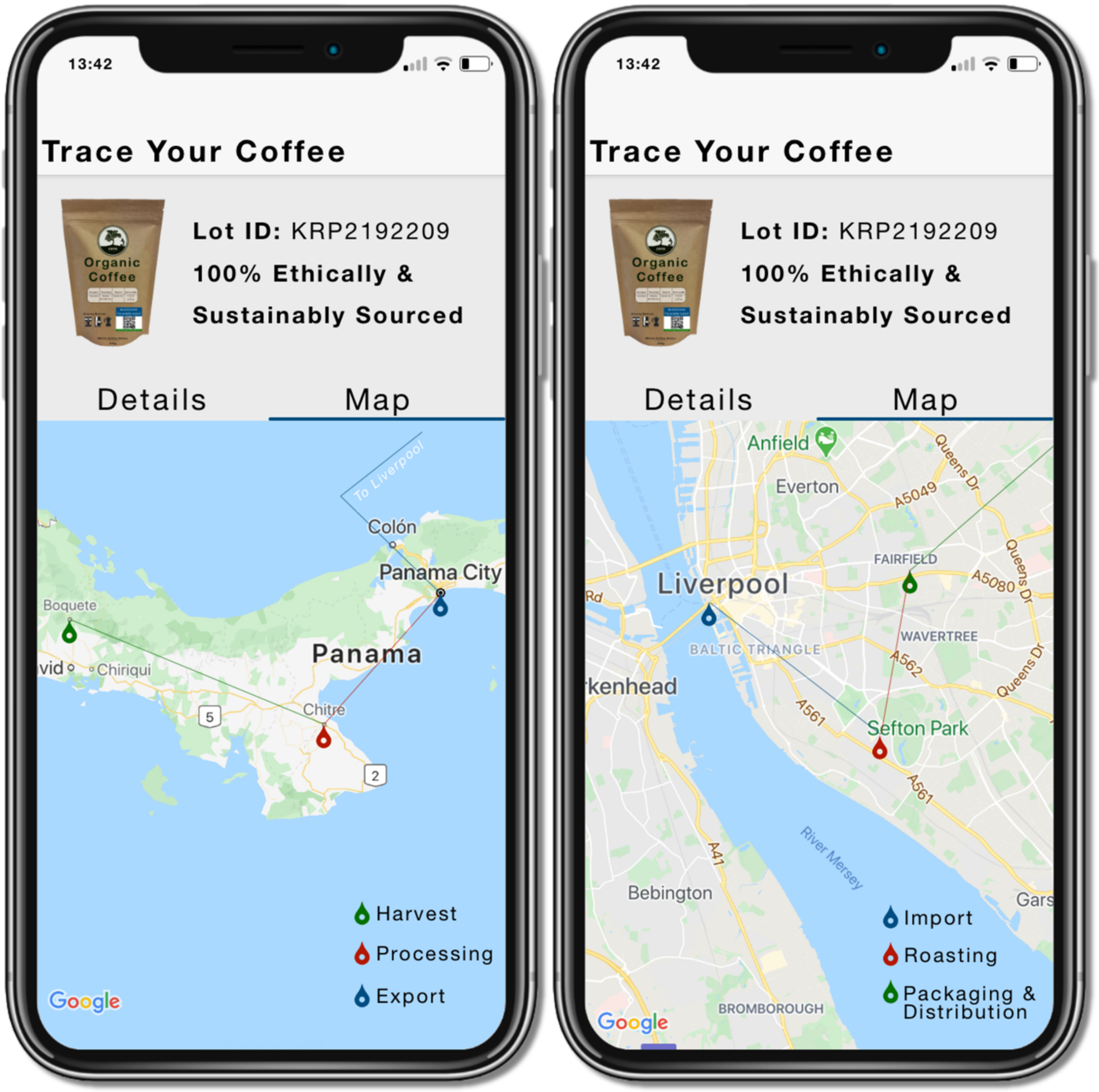
Overall, UTZ, like other no-profit certification bodies, provides standards and good practices throughout the coffee supply chain as well as the traceability system in order to make sure these practices are being implemented and monitored. However, the end consumer has no direct access to its traceability platform and has to trust UTZ that its claims hold true.

Blockchain Traceability App Visual Aid (Details) (Figure 35)



Upon scanning the QR code on your product you will see a number of details about your product's journey starting from the harvesting of the coffee cherries in Panama all the way to the roasting process in Liverpool along with corresponding dates and transaction IDs as they were recorded in the Blockchain system.

Blockchain Traceability App Visual Aid (Map) (Figure 35)



Moving to the second tab in the app (titled Map) you will see your product's journey laid out in a world map with all key locations pinned as they were recorded in the blockchain system.

Appendix 3: Study 3 Additional Materials

Research Ethics Approval

University of Nottingham
UK | CHINA | MALAYSIA

Faculty of Social Sciences
Nottingham University Business School
University of Nottingham
Jubilee Campus
Nottingham
NG8 1BB

22 June 2021

To whom it may concern,

Ethics Review Application No.: 201929117 - Blockchain Technologies for Supply Chain Management and Product Traceability: Industry Considerations and Consumer Preferences - Symeon Dionysis

I am writing as chair of the Nottingham University Business School Research Ethics Committee (NUBS REC) to confirm a favourable ethical opinion for the above research on the basis of the documentation submitted below. This opinion was given on the above stated date.

The School REC operates according to the University of Nottingham's *Code of Research Conduct and Research Ethics, and the Economic and Social Research Council (ESRC) Framework for Research Ethics.*

The documents reviewed and approved are:

- NUBS REC Ethics Review Checklist
- Research Participant Information Sheet
- Research Participant Privacy Notice
- Research Participant Consent Form
- Research Participant Instructions

The following conditions apply to this favourable opinion:

1. The research must follow the protocol agreed and any changes will require prior NUBS REC approval.

For further information about the School's Research Ethics Committee or approval process, please contact the Research Ethics Officer, Davide Pero at davide.pero@nottingham.ac.uk or +44 (0)115 84 67766.

Yours faithfully,

AJ Crompton

Dr Amanda Crompton
Chair of Nottingham University Business School Research Ethics Committee

Organic Coffee Visual Aids & Product Description (No Traceability Certification) (No. 1 in Figure 36)

Our deep love for coffee can only emerge from the most profound respect for nature. That's why Greco Coffee was established on the principles of **environmental sustainability** and **social responsibility**. Our purpose is to offer you the best quality of coffee and a pure product you can daily enjoy with peace of mind. By using the finest beans, the world has to offer and by maintaining the highest production standards, our organic coffee is consistently full-flavoured and always smooth.

In contrast to other coffee brands that mix-match coffee beans from various plants and countries around the world, resulting in you getting an inferior product, our bags are filled with **single-source** beans for the same farm, the same plant, and the same roasting profile. In that way, we can ensure that our coffee is pesticide and mycotoxin free. We collaborate directly with the highest quality farms located in a nationally protected, high-altitude area of Central America, which supply us with beans of exceptional flavour and vibrancy.

The farmers ensure that their plants are **shade-grown**, and no direct sunlight hits the coffee cherries harming their natural maturation process and affecting their flavour. Only once the beans are collected, they are sun-dried until they've achieved a moisture content of 11.5%, followed by a 30-day rest period that allows your beans' flavour profile to emerge and deepen in richness, complexity, and taste. The beans are then carefully roasted in our state-of-the-art facilities in Jersey City. Our experienced roast masters understand the nuances and delicacies involved in this process and roast our beans to exact specifications to produce delicious, low-acid coffee you will love.

In choosing our coffee, you are getting a trusted, high-quality product that you know is grown in a sustainable, **fair trade** environment by farmers that care about their local ecosystem and who are paid a fair wage for their essential effort. Our coffee is suitable for bean to cup coffee machines, Cafetieres, AeroPress, Chemex, or Mocha Pots.

Organic Coffee Visual Aids & Certification Description (Condition A: Company Initiative) (No. 2 in Figure 36)

Building and maintaining strong, healthy, professional, and friendly relationships with our partners throughout the supply chain is a crucial factor for our success. That is why we have established Project Sustainable; a Greco Coffee in-house initiative developed to ensure and guarantee that our organic coffee production practices are not only environmentally and socially responsible but also transparent. This initiative is built around three pillars: sourcing and farming practices, shipping and transpiration, and processing and manufacturing.

Sustainable sourcing of our coffee beans is only achieved by working closely with farmers and supporting them in every step of the process. It is a close partnership where shared goals and a holistic approach to both the ecosystem and the people around it are needed. That's why we travel and visit each farm directly and conduct audits in collaboration with our partner producers. We collect all relevant information via interviews, observing their facilities and production processes and compile everything into impact reports for each farm we work on. In that way, we can ensure the quality of our product and transparently record and measure the progress and success of our business relationships.

We make sure that coffee beans are securely prepared and are vacuum packed in 60 kg or 70 kg in laminated multilayer polythene 'GrainPro' bags that protect the beans from moisture, temperature, and air quality changes. We also collaborate with other coffee exporters and cooperatives in order to reduce the environmental impact of shipping and transportation. Our roasting facilities strictly follow FDA's Good Manufacturing Practices to ensure and promote sanitary practices, sanitary design, and sanitary environment, as well as the Hazard Analysis and Critical Control Points in order to prevent any form of biological, chemical, and physical hazards affecting our final product.

By closely following the three pillars of Project Sustainable, Greco Coffee can guarantee that our organic coffee is of the finest quality and is grown, harvested, and processed in a transparent, sustainable, and responsible way.

Organic Coffee Visual Aids & Certification Description (Condition B: Third-Party Certification) (No. 3 in Figure 36)

UTZ (meaning "good coffee" in the Guatemalan Mayan language of Quiché) is a non-profit organisation founded in 2002 by Nick Bocklandt and Ward de Groote with the goal to bring sustainable coffee certification for consumers to the global market as well as promote sustainable farming practices. UTZ is the largest program for sustainable coffee and cocoa farming in the world, while they also provide services for tea and hazelnuts. In 2018 UTZ merged with Rainforest Alliance, and they are currently working on a common certification program.

UTZ sets quality standards both for farmers as well as for supply chain actors. These standards are developed in collaboration with external bodies, NGOs, and all actors throughout the supply chain. UTZ standards are divided into two sections. The first is the code of conduct, targeted toward farmers, and covers aspects of management, farming practices, working conditions and environmental protections. The second section of the standards is the chain of custody, targeted toward supply chain actors, and addresses administrative practices and product traceability.

After finalising these standards, UTZ trains what they call capacity builders. These agents will train the farmers on the organisation's code of conduct and sustainable farming practices. At the same time, UTZ trains external certification bodies, which will be responsible for auditing both farmers against the code of contact as well as supply chain actors against the chain of custody.

Traceability of products, referring to the ability to identify and verify the components and chronology of events in all steps through a product's journey, is one of the most significant aspects of UTZ certification. Using the Good Inside Platform, UTZ is tracking their product's journey from farmers to processing and from transportation to manufacturing to the end retailer, so consumers can be confident that the UTZ labelled product they are buying comes from certified sources. This traceability system, however, still requires a lot of paperwork and record-keeping as well as several different parties to facilitate it.

Overall, UTZ, like other no-profit certification bodies, provides standards and good practices throughout the coffee supply chain as well as the traceability system in order to make sure these practices are being implemented and monitored.

Organic Coffee Visual Aids & Certification Description
(Condition C: Third-Party Certification & Interactive Barcode)
(No. 4 in Figure 36)

UTZ (meaning "good coffee" in the Guatemalan Mayan language of Quiché) is a non-profit organisation founded in 2002 by Nick Bocklandt and Ward de Groote with the goal to bring sustainable coffee certification for consumers to the global market as well as promote sustainable farming practices. UTZ is the largest program for sustainable coffee and cocoa farming in the world, while they also provide services for tea and hazelnuts. In 2018 UTZ merged with Rainforest Alliance, and they are currently working on a common certification program.

UTZ sets quality standards both for farmers as well as for supply chain actors. These standards are developed in collaboration with external bodies, NGOs, and all actors throughout the supply chain. UTZ standards are divided into two sections. The first is the code of conduct, targeted toward farmers, and covers aspects of management, farming practices, working conditions and environmental protections. The second section of the standards is the chain of custody, targeted toward supply chain actors, and addresses administrative practices and product traceability.

After finalising these standards, UTZ trains what they call capacity builders. These agents will train the farmers on the organisation's code of conduct and sustainable farming practices. At the same time, UTZ trains external certification bodies, which will be responsible for auditing both farmers against the code of contact as well as supply chain actors against the chain of custody.

Traceability of products, referring to the ability to identify and verify the components and chronology of events in all steps through a product's journey, is one of the most significant aspects of UTZ certification. Using the Good Inside Platform, UTZ is tracking their product's journey from farmers to processing and from transportation to manufacturing to the end retailer, so consumers can be confident that the UTZ labelled product they are buying comes from certified sources. This traceability system, however, still requires a lot of paperwork and record-keeping as well as several different parties to facilitate it.

Overall, UTZ, like other no-profit certification bodies, provides standards and good practices throughout the coffee supply chain as well as the traceability system in order to make sure these practices are being implemented and monitored.

Organic Coffee Visual Aids & Certification Description (Condition D: Blockchain Platform) (No. 5 in Figure 36)

Blockchain technologies were introduced in 2008 as the supporting infrastructure of Bicton. Although the use of the technology was initially limited to digital currencies, throughout the years, researchers and companies realised the potential of blockchain and started utilising it to address the long-standing issues of transparency and traceability in supply chains.

In its simplest form, blockchain is a distributed ledger, a database containing information shared across a network of computers. A set of such databases can create a block which is then cryptographically sealed. Everyone in the network has access to that ledger (hence, the word distributed). When someone wants to update the ledger, a new block is created containing the updated datasets as well as all the information from the previous blocks. In time, this forms a chain of blocks that are distributed across the network and cannot be tampered with since it will alter the chain and it will be immediately spotted. Digital signatures and cryptography also verify the validity and authenticity of an update request, making sure it's genuine.

Several companies have been experimenting with utilising blockchain technologies to enhance transparency and traceability in coffee products, both for farmers and supply chain actors as well as for the consumer. After farmers harvest the coffee cherries, all data related to their crops are uploaded to the blockchain. Relevant data will also be uploaded during the processing of those cherries. The processed beans will then be shipped to various markets, with all shipping information being tracked in the system. During the roasting process, information, including grades and blends, will be updated.

The final packed product will be equipped QR code allowing consumers to check themselves their coffee's journey. During all points of the coffee's journey, from farmer to consumer, all information is kept in a single secure system instead of a cumbersome and complex paper trail process. It is the same system that consumers are getting partial access to when scanning the QR code, allowing for reliable information regarding the journey of their coffee, even, in some cases, allowing them to thank or support the farmers directly.

Overall, Blockchain Certification not only enhances transparency and traceability in the coffee supply chain, but it also carries those benefits to the end consumers by allowing them to access part of the system in ways that traditional certification, like UTZ, does not.

Organic Coffee Visual Aids & Certification Description.

(Condition E: Blockchain Platform & Third-Party Certification)

(No. 6 in Figure 36)

Blockchain technologies were introduced in 2008 as the supporting infrastructure of Bicton. Although the use of the technology was initially limited to digital currencies, throughout the years, researchers and companies realised the potential of blockchain and started utilising it to address the long-standing issues of transparency and traceability in supply chains.

Several companies have been experimenting with utilising blockchain technologies to enhance transparency and traceability in coffee products, both for farmers and supply chain actors as well as for the consumer. After farmers harvest the coffee cherries, all data related to their crops are uploaded to the blockchain. Relevant data will also be uploaded during the processing of those cherries. The processed beans will then be shipped to various markets, with all shipping information being tracked in the system. During the roasting process, information, including grades and blends, will be updated.

The final packed product will be equipped QR code allowing consumers to check themselves their coffee's journey. During all points of the coffee's journey, from farmer to consumer, all information is kept in a single secure system instead of a cumbersome and complex paper trail process. It is the same system that consumers are getting partial access to when scanning the QR code, allowing for reliable information regarding the journey of their coffee, even, in some cases, allowing them to thank or support the farmers directly.

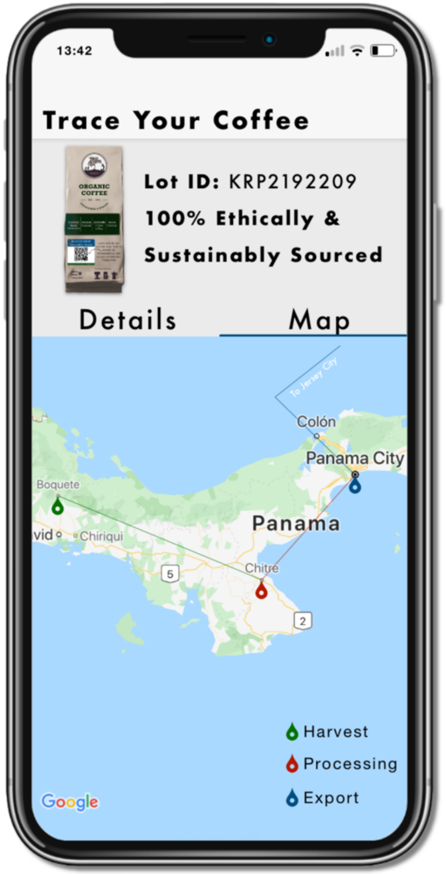
In addition to using Blockchain technologies to trace our product transparently, we also utilise UTZ certification to verify the farming conditions of our producers. UTZ (meaning "good coffee in the Guatemalan Mayan language of Quiché) is a non-profit organisation founded in 2002 by Nick Bocklandt and Ward de Groote with the goal of bringing sustainable coffee certification for consumers to the global market as well as promoting sustainable farming practices. UTZ is the largest program for sustainable coffee and cocoa farming in the world. In 2018 UTZ merged with Rainforest Alliance.

By collaborating with external bodies, NGOs, and all actors throughout the supply chain, UTZ sets quality standards for farmers, covering aspects of production management, farming practices working conditions and environmental protections. After finalising these standards, UTZ trains what they call capacity builders. These agents will train the farmers on the organisation's code of conduct and sustainable farming practices.

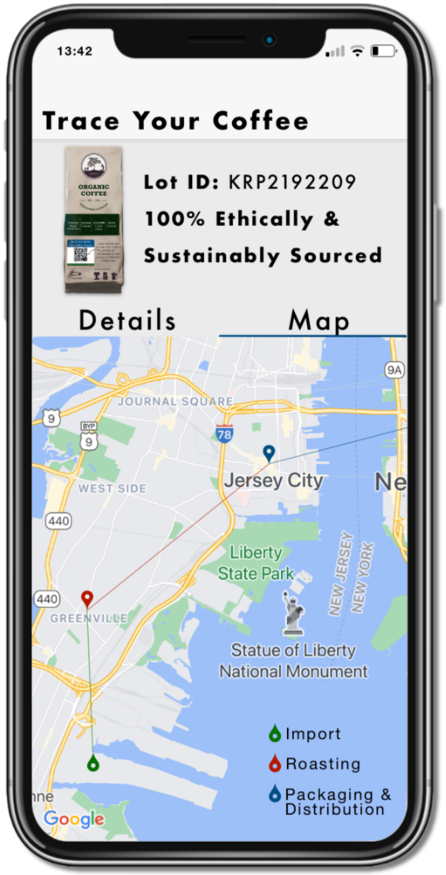
Blockchain Traceability App Visual Aid (Condition D: Blockchain Platform) (Figure 38)

Details 1/2

Details 2/2



Map 1/2



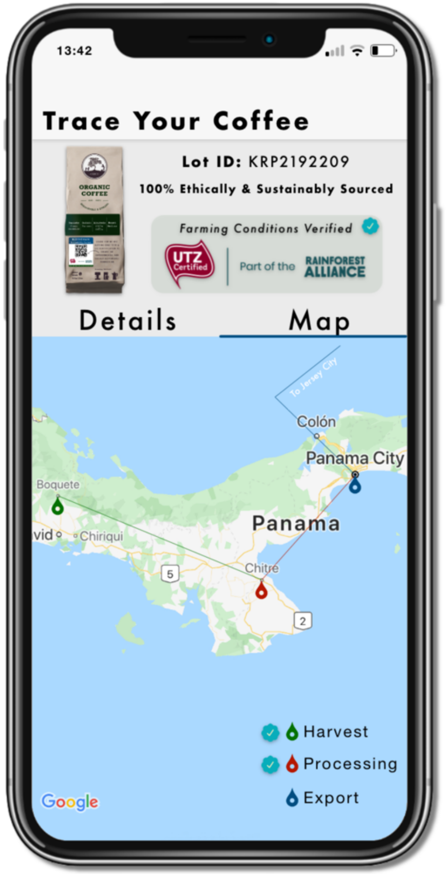
Map 2/2

Blockchain Traceability App Visual Aid

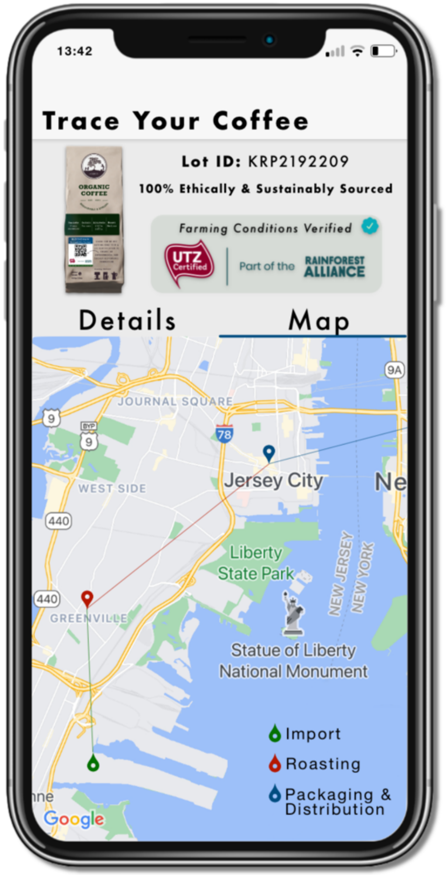
(Condition E: Blockchain Platform & Third-Party Certification) (Figure 39)

Details 1/2

Details 2/2



Map 1/2



Map 2/2

Appendix 4. PhD Portfolio

Horizon Centre for Doctoral Training Taught modules

	Title	Code	Credits
	Compulsory Modules		
1.	Innovation & Society	L34117	10
2.	Innovation & Technology Transfer	N14T15	10
3.	Practise Led Project	G54PLP	30
	(The Psychological Antecedents of Luxury Brand Choice)		
4.	Enabling Technologies	G54ENA	20
5.	Global Impacts	G54GLO	10
6.	Advanced Research Methods & Ethics	G54ARM	10
7.	Graduate School Research & Professional Skills	G54RP2	10
8.	Reflections on Internship	G54INT	20
9.	Outreach & Exhibitions	G54OUT	10
10.	PhD Research Proposal	G54URP	20
	Optional Modules		
1.	Programming (Python)	G54PRG	20
2.	Human - Computer Systems	MM4HCI	10
		TOTAL	**180**

Graduate School Courses

	Title	Training Units
1.	Small Group Teaching (NUBS)	1
2.	Research ethics for Doctoral Researchers	1
3.	Research Interview Skills	2
4.	Doing Focus Group Research	2
5.	Introduction to qualitative research	2
6.	Further qualitative research	2
7.	Introduction to Database Design	1
	TOTAL	**11**

Internship

– Between August to October 2019, I undertook an internship/placement at my PhD external partner, the Digital Catapult Centre in London. Digital Catapult functions as a digital technology accelerator and innovation centre and is part of the Innovate UK Catapult Network. As part of the policy and research team, my role focused on mapping the UK's blockchain and DLT market and developing a survey tool/questionnaire for that market, which was the basis for the tool used in Chapter 4.

Teaching

	Title	Code	Year
1.	Computers in Business (Course Excel Tutorials)	BUSI1001	2018 - 2020
2.	Managing Operations in Digital Enterprise (Course Seminars)	BUSI1032	2019 - 2020
3.	Purchasing Strategies and Techniques (Course Negotiation Exercises)	BUSI3037	2019 - 2020 2021 - 2022

Inspire Foundation Nottingham

- Inspire Foundation was established in early 2019 by a group of researchers/employees of the University of Nottingham as well as individuals from across the city with the goal to bring together and integrate new and established communities through cultural and educational events and activities. These range from weekly STEM Saturday Clubs aimed at young people between 11-15 years of age from disadvantaged and potentially vulnerable backgrounds to participating in community and cultural events and exhibitions. I have been an active member of Inspire Foundation since 2019, and for the past two years, I have been a trustee for the charity.

Presentations and Activities

- *Exploring Consumers' Purchase Intentions for Blockchain Traceable Coffee.*
  Presentation at the Midlands Doctoral Conference 2021, Nottingham, UK.
  (Best Presentation Winner in the Sustainability, Well-Being, and Resilience Session)

- Since 2022, I have served as a reviewer for the ACM Journal: Transactions on Computer-Human Interaction.

Publications

Dionysis, S., Chesney, T., & McAuley, D. (2022). Examining the influential factors of consumer purchase intentions for blockchain traceable coffee using the theory of planned behaviour. *British Food Journal*, *ahead-of-print(ahead-of-print)* - (Chapter 5).

Dionysis, S., Chesney, T., & McAuley, D. (2022). Blockchain traceability certification for organic coffee: A study of multiple labels and consumer preferences. *International Journal of Consumer Studies, in preparation* - (Chapter 6).