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Blockchain in Supply Chain

It's (not) a matter of trust

by

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Abstract

Title: Blockchain in Supply Chain: *It's (not) a matter of trust*

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Keywords: Blockchain, Supply chain, Customer benefits, Traceability, Transaction costs, Transparency, Trust, Value, Value creation.

Purpose: the purpose is to unveil the determinants of value creation in the supply chain and to analyse the role of blockchain in this ecosystem. Furthermore, the study aims at determining whether these factors have causal, linear or bidirectional linkages between each other and if they directly influence both sides of value – benefits and costs.

Methodology: the study follows a qualitative research design with a single case study, specific to dairy industry, embedded in a broader description of blockchain and supply chain in related industries. Beyond primary sources, secondary data will also be used for additional perspectives and clarification.

Theoretical perspectives: the study is based on Transaction Cost Economics and value creation, combined with blockchain literature in supply chain management. These theories form the foundation for the creation of our theoretical framework, whose aim is to visualize how blockchain creates value in the supply chain.

Empirical foundation: Western Europe and the dairy industry are the chosen settings for this thesis. This context was chosen due to promising use cases of blockchain in dairy supply chain. Growing awareness from consumers is spurring the demand for more comprehensive information regarding products' journey throughout the supply chain.

Conclusion: value in supply chains is influenced by traceability, transparency and trust. Blockchain increases these factors and enables value creation opportunities in the form of reduced transaction costs and increased customer benefits. The benefit side plays the biggest role and is greatly influenced by transparency.

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1 Introduction

"World trade means competition from anywhere; advancing technology encourages cross-industry competition. Consequently, strategic planning must consider who our future competitors will be, not only who is here today." -- Eric Allison, Uber.

1.1 The Paradox of Blockchain

In the past, incumbency was such a strong advantage that dominant companies did not have to move as quickly as smaller rivals. More recently, however, digital technologies have allowed new business models to spread much faster. The value of speed has increased, and the incumbent company's advantage has declined. In some cases, the assets that once made up the incumbent's advantage have now become liabilities (Morrisey & Lancry, 2018). Through globalization and digitalization, competition has increased remarkably and a growing emphasis on competing as a supply chain rather than as a single company is gaining traction. Companies such as IKEA and Nike have achieved competitive advantage by managing their supply chain with excellence and focusing on their core competencies. But relying on separate entities to deliver components and products necessary for your business implies risks and costs in order to hedge yourself, and these costs are referred to as transaction costs. Transaction costs were first introduced by Coase (1937) and later elaborated by Williamson (1975, 1985). They are the costs associated with transactions and aim to explain how companies govern their structure. In today's modern societies, specialization is constantly increasing. This specialization requires increasing percentages of the society to be employed in transacting, resulting in the transaction sector to be a big part of the gross national product. In 1970 the transaction sector was a staggering of 45% of the GNP in the US compared to 25% in 1870 (Wallis and North, 1986). Several authors highlight trust as a safeguard against opportunism, thus lowering transaction costs, and supply chain management put high emphasis on increasing trust and thus collaboration between the actors (Sako, 1991; Zajac and Olsen, 1993; Francisco and Swanson, 2018). Lately, blockchain has been portrayed as a possible solution to both trust and supply chain management (Marr, 2018; Barcus, 2019). The blockchain is the technology behind the

cryptocurrency Bitcoin and is a digital, distributed ledger. The technology promises to solve the issues of trust in supply chains, by providing an irreversible and chronological audit trail of the transactions conducted. By increasing transparency, it can mitigate the mistrust that often exists among the supply chain transacting partners. Yet, this same mistrust makes it hard to bring together the industry's diverse participants into a common blockchain ecosystem (Schmal et al., 2019). In a recent survey, the respondents depicted trust as one of the biggest barriers to blockchain implementation, being second to only regulatory uncertainty (PWC, 2018). The same issue that blockchain is aiming to combat is hindering its nascency. This is the paradox of blockchain.

1.2 Problematization

As mentioned above, trust is one of the supply chain issues that blockchain aims to solve. By enabling transparency across the transacting partners that participate in the blockchain, a new ecosystem based on trust can be enhanced (Barcus, 2019). When considering how value can be created with blockchain in the supply chain, both sides of the equation should be taken into account: reducing transaction costs, and increasing consumers' willingness to pay higher prices on the other. But what are the determinants of this perceived consumer benefits? In a recent report, more than two thirds of consumers (74%) declared that they would switch brands if their current brand choice lack transparency regarding product details (Label Insight, 2018). This opens opportunities for organizations that aim to recapture value in the form of trust from their consumers.

The growing awareness and consciousness of consumers are also impacting the dairy industry. The traditional value drivers of price, taste, and convenience have been supplemented by evolving drivers of health and wellness, safety, social impact and experience (Deloitte, 2017). These soft values, such as how the product was made, where it was made, and corporate values of the manufacturer and retailer, are becoming increasingly crucial. The exacerbated importance of knowledge about the entire supply chain also have direct implications on the profits of the companies. In December 2017, this became tangible in the dairy industry when salmonella bacteria were found in a factory belonging to the French company Lactalis. At least 35 babies have fallen ill in France alone, and additionally, more than 12 million boxes of

powdered baby milk have been recalled in 83 countries (BBC, 2018). One way for companies to mitigate this phenomenon is by implementing blockchain in their supply chain. Walmart and IBM are in the forefront in this area and are working on a food safety blockchain solution (Miller, 2018). By placing the entire supply chain on the blockchain, the process becomes more traceable, transparent and fully digital. Consumers would be able to trace the origin of the product and companies would - on a granular level, much faster and easier - be able to tell which products should be recalled with greater precision depending on the affected source. Walmart states that before moving the process onto the blockchain, it typically took approximately seven days to trace the source of the food, but with the blockchain it's been reduced to 2.2 seconds (Miller, 2018). However, blockchain is still in its infancy and the questions regarding the implementation and applicability are vast. According to several authors, the digitalization will have a huge impact on the value chain, and some are comparing the potential impact of blockchain to the impact of the internet. The technology could render parts of the value chain obsolete and completely alter the relationships between the actors. But as with every investment, and new technology, a cost-benefit analysis is essential. Implementing emerging, innovative solutions just for the sake of having them can be a caveat and it is important to comprehend both the pros and cons with the technology. On the other hand, the fear of being left at the platform when the train departs might trump the rational approach of evaluating the option.

1.3 Research Question

Deriving from the above background and problematization, this paper has the ambition to answer the following question:

How can blockchain enable value creation in the supply chain?

1.4 Research Purpose

Although blockchain technology is a relatively new concept - the very first application was Bitcoin, just a decade ago - there is already substantial literature that covers its applicability in the food supply chain, with a few examples also in the dairy industry. This ensures that the topic has drawn enough attention in the academic world and not only in the business side. Nonetheless, we argue that a new conceptualization of blockchain, with TCE and Value Creation as the guiding references, is worth investigating. To be specific, our main purpose is to unveil the determinants of value creation in the supply chain and to analyse the role of blockchain in this ecosystem. We also want to determine whether these factors have causal, linear or bidirectional linkages between each other and if they directly influence both sides of value – benefits and costs. The collection of primary and secondary data together with a comprehensive literature review of these concepts will possibly help us fulfilling our purpose. After the literature review, an initial framework will be presented and this will guide us through the collection of the empirical data. An analytical discussion will then aim at revisiting this framework.

1.5 Research Limitations

The limitations of this paper are mainly related to its scope. Firstly, the choice of Western European countries as the focus limits the findings and their implementation to similar economies, therefore potentially only to Western developed states. Secondly, the selection of a specific supply chain for the validation of the theoretical framework limits the conclusions that can be drawn from the empirical evidence to other supply chains of similar length and complexity. The industry chosen additionally narrows down the findings to other competitive, price pressured industries, potentially only ones handling perishable products. Furthermore, the unit of analysis will be mainly the producer, leaving other parts of the supply chain less examined. Nevertheless, the thesis will provide a higher degree of abstraction in the analysis and conclusion sections to allow for more generalizable findings and aid more practitioners. The fact that we are mainly interviewing companies involved in blockchain could potentially leave us with a biased, and overly positive, image of reality. And even if we will try putting

them on the stand about challenges and downsides of blockchain, we believe the majority will be enthusiastic about the technology and might diverge from the truth. It must also be mentioned that trust is an intangible, subjective notion and individuals' interpretations regarding it might be difficult to operationalize. This in junction with a qualitative approach might derive less generalizable findings. Lastly, this paper has not the ambition to deeply analyse the technical elements that are behind blockchain technology, considering that academic works have already been produced about this aspect, but rather analysing the strategic implications of the technology in the supply chain field.

1.6 Thesis Outline

The following chapters highlight our progress in the effort of fulfilling our research objectives. In Chapter 2, a literature review of TCE and Value Creation models is presented, in conjunction with substantive papers in the field of blockchain technology. The chapter ends with presenting a framework that aims at helping the reader better visualize the theoretical implications that guide the data collection. Chapter 3 is then dedicated to show the methodology approach that has been followed in the research design, as well as the choice of dairy supply chain and blockchain technology. The paper continues with Chapter 4 that focuses on the data gatherings and empirical findings from both primary and secondary sources. Chapter 5 is then committed to the analysis of the data collected and summarized in the previous chapter. Chapter 6 concludes the paper, outlining limitations as well as opportunities for further investigations of the matter.

2 Literature Review

This literature review aims at producing a comprehensive understanding of selected bodies of theories that harmonize blockchain implications in supply chain. The most relevant were Transaction Cost Economics and Value Creation in the strategic management field. These theories are then supported with their connection to blockchain literature, thus helping the reader understanding the relevant interlinkages. The chapter ends with a proposed framework, based on the mentioned theories, that will form the basis for analysis and discussion.

2.1 Transaction Cost Economics

The provocative paper *The nature of the Firm* by Ronald Coase (1937) emphasized that firms and markets were alternative means for the same issue, organizing transactions (Powell, 1990). Coase's paper did not receive too much attention until it was picked up by Williamson and other proponents of transaction cost economics in the 1970s (Powell, 1990). The proliferation of the theory was driven by Williamson who argued that transactions that involve uncertainty about the outcome, recur frequently and require substantial "transaction-specific investments", have a higher propensity to occur within hierarchically organized firms (Williamson, 1975; 1985). Transaction-specific investments or assets, also known as the degree of asset specificity or relation-specific investments, refer to resources that cannot be easily, or without a substantial cost, transferred to another use (Williamson, 1979). Exchanges which are straightforward, non-repetitive and do not require transaction-specific investments will take place on the marketplace. The transaction costs related to market transactions are assumed to be positively correlated with the determinants of frequency, uncertainty and asset specificity. Thus, as asset specificity increases, the transaction costs associated with the transaction increases and the governance structure will move from markets toward hierarchies (Powell, 1990). The underlying behavioural assumptions of the theory, which are fuelling this notion, are that humans, and thus companies, are restricted by bounded rationality and opportunism

(Williamson, 1985). Bounded rationality means that humans' behaviour is "intendedly rational, but only limited so" (Simon, 1961, p 24), resulting in incomplete contracts which fail to cover all possible contingencies (Powell, 1990). Opportunism, on the other hand, refers to the greedy side of people and is a condition of "self-interest seeking with guile" (Williamson, 1985), where economic actors seek to pursuit outcomes reflecting their interest with any means at their disposal (Powell, 1990). The degree of opportunism and bounded rationality are positively correlated with vertical integration, but are undoubtedly difficult to measure beforehand. Alchian et al. (1978) highlight that when assets become more specific, the possible gains from opportunistic behaviour increase and the risk of quasi-rents become present. The quasi-rent value of the asset or resource is the excess over its salvage value, that is, its value to the next best buyer or user. As assets and resources become more specific and higher appropriable quasi-rents are created, the costs of contracting will generally increase more than the costs of vertical integration because transactors must safeguard themselves against the hazards of opportunism (Alchian et.al., 1978; Williamson, 1985). The different determinants are thus interconnected and inflates the influence of others and this augmentation must be reflected when determining the shape of the governance structure.

2.1.1 Governance Structures

The governance structure of companies may take many shapes but the two extremes, and main alternatives according to Williamson (1979), are market and hierarchy. This notion of sharp firm boundaries was shared by management practitioners and antitrust law (Powell, 1990) with the belief that firms were "islands of planned co-ordination in a sea of market relations" (Richardson, 1972). This belief is today long gone and economic exchange can be arrayed in a continuum-like fashion with highly centralized firms at one end and market transactions at the other (Powell, 1990). Williamson revised his viewpoint in 1985 and acknowledged that governance structures between the two extremes are much more common but still viewed the transaction cost theory as the best tool to explain the "Make or Buy" spectrum of transacting. Empirical studies have shown that the transaction cost theory somewhat corresponds with reality but critics point out that there are successful companies within the same industry on the entire Make or Buy Spectrum (Moran & Ghoshal, 1996). The scepticism toward Williamson's approach grew and many accentuated that the model was too simplified to explain the

governance structure. Powell (1990) emphasized on the role of reciprocity and collaboration between the actors as an alternative governance mechanism. Stinchcombe (1985) drew connections between the two extremes and showed that there are strong elements of hierarchy and domination also in written contracts. Numerous market transactions have been replaced by interorganizational collaborations characterized by long-term, complex and multiparty contractual relationships (Goldberg, 1980). Powell (1990) introduced the network as a distinctive form of coordinating economic activity and emphasized that the social factor of transactions is more relevant than it is ascribed in the transaction cost theory. The economic exchange is "dependent on relationships, mutual interests and reputation" and distinguishing separate entities become harder when relations are long-term and transactions are reoccurring (Powell, 1990). The collaboration between actors therefore become imperative in order to succeed, especially in a more globalized and complex world. Hernández and Pedersen (2017) are on similar track and highlight the importance of deepened collaboration with other actors as crucial in order to stay competitive in an ever-changing world. However, the risk of opportunistic behaviour from counterparties is still present.

2.1.2 Opportunistic Behaviour

The plain fear of opportunistic behaviour can have negative implications on all the actors involved, especially during relationship-specific investments. As a result, the propensity of suppliers or buyers making specific investments, which could increase the overall value and efficiency, decreases in order to avoid being "locked in" by the transacting partner (Alchian et.al., 1978). According to Hill (1990), the risk of opportunistic behaviour is exaggerated though, especially due to the force of the invisible hand. He argues that the market will mitigate this issue by making it harder and costlier for opportunistic actors to make transactions in the future, thus leading to the presence of a moral compass in the business arena. However, for an individual company, this leap of faith towards the marketplace could prove to be an ominous approach and lead to huge short-term losses if the counterparty decides to act opportunistically. If supply chain actors would be able to trust that other firms avoid opportunistic behaviour and conduct business in a fair way, there would be mutual benefits to gain. Relying blindly on other actors for critical components is risky though, and may lead to bottlenecks in the production or

short-term losses. Exchanges characterized by this uncertainty results in transactions that are more conducive toward opportunism (Walker and Weber, 1984; Williamson, 1985).

2.1.3 Uncertainty and Trust

Williamson (1979) portrays uncertainty as the most critical attribute in determining how to manage transactions, and greater uncertainty related to a specific transaction increases the costs associated with market contracts (1975; 1985). Uncertainty can be related to time of delivery, or quality of the delivered merchandise. Contracts are stipulated ex ante in order to lower the uncertainty but due to bounded rationality, all the possible events are impossible to cover and the contracts are thus incomplete (Williamson, 1985). In the absence of uncertainty, even highly specialized assets may be protected contractually; and Williamson stressed that one should assume that uncertainty is always present at least in a nontrivial degree (Mahoney, 1992; Williamson, 1985). Thus, transaction costs mainly arise from mitigating uncertainty in an economic transaction. Uncertainty can be reflected by a lack of trust, and increased trust should logically decrease the perceived degree of uncertainty. Williamson (1985) confirms that trust is an essential part in business but is not incorporated in the mainstream model of TCE, mainly because it is difficult to operationalize (Williamson, 1975). Trust in this context can be defined as "consisting of actions that (a) increase one's vulnerability, (b) to another whose behavior is not under one's control, (c) in a situation in which the penalty (disutility) one suffers if the other abuses that vulnerability is greater than the benefit (utility) one gains if the other does not abuse that vulnerability" (Zand, 1972). If trust is absent and contracts are too expensive to stipulate, there will be a lower degree of relation-specific investments which could have mutual benefits for the transactors. Empirical work has shown that investments in relation-specific assets are correlated with superior performance (Dyer, 1996; 1997).

2.1.4 Trust and Supply Chain

As mentioned before, companies have the opportunity to vertically integrate activities when the costs of integrating are lower than the contracting costs associated with the activity. Using the market implies that the exchange is clearly specified, trust is not required, and agreements are

bolstered by legal sanctions (Powell, 1990). Vertically integrating, on the other hand, is a way to secure resources within the company but it also increases the complexity of the organization and could lead to negligence of the company's core competencies. It is therefore a trade-off for companies to decide whether to outsource activities or integrating activities in their own supply chain. Indeed, companies like Nike and IKEA has achieved strong competitive advantage by outsourcing their supply chain and focusing on their core competencies. In the modern economy, the value chain is characterized by interfirm specialization where firms engage in a narrow range of activities which are embedded in a complex chain of input-output relationships with other firms (Dyer, 1997). Value chain improvements are facilitated when companies are willing to make transaction or relation-specific investments (Williamson, 1985; Perry 1989). However, outsourcing the manufacturing and focusing on core competencies within a production network implies a risk, and a potential cost. When asset specificity increases, complex contracts are required to attenuate or eliminate the fear of opportunism (Williamson, 1985). Although contracts are viewed as the primary mean to protect against the hazards of opportunism, other safeguards have been offered (Dyer, 1997). The most typical ones are "self-enforcing" agreements or "trust" (Telser, 1980; Sako, 1991). They include informal safeguards such as relational or goodwill trust (Dore, 1983; Bradach & Eccles, 1989; Sako, 1991) and reputation (Kreps & Wilson, 1982; Weigelt and Camerer, 1988). Beyond cost minimization, Zajac and Olsen (1993) argue that parties should be concerned with maximizing the value through value creating initiatives. They emphasize that the transaction cost approach is limited and neglects the interdependence between exchange parties in the pursuit of joint value (Zajak and Olsen, 1993). Interdependence and the quest for synergistic relationships are thus essential in successful supply chains. Larson and Kulchitsky (2000) came to the conclusion that closer relationships between supplier and buyer firms translates into superior delivery performance by the suppliers. Collaboration is critical for superior supply chain performance and it is suggested that trust between the actors result in better business relationships. However, increased cooperation often implies sharing knowledge to a greater extent. Sharing information among supply chain actors may involve the release of proprietary financial, and/or operational information which can be abused (Kwon and Suh, 2004). The concept of information sharing will be further elaborated below.

2.2 TCE and Blockchain

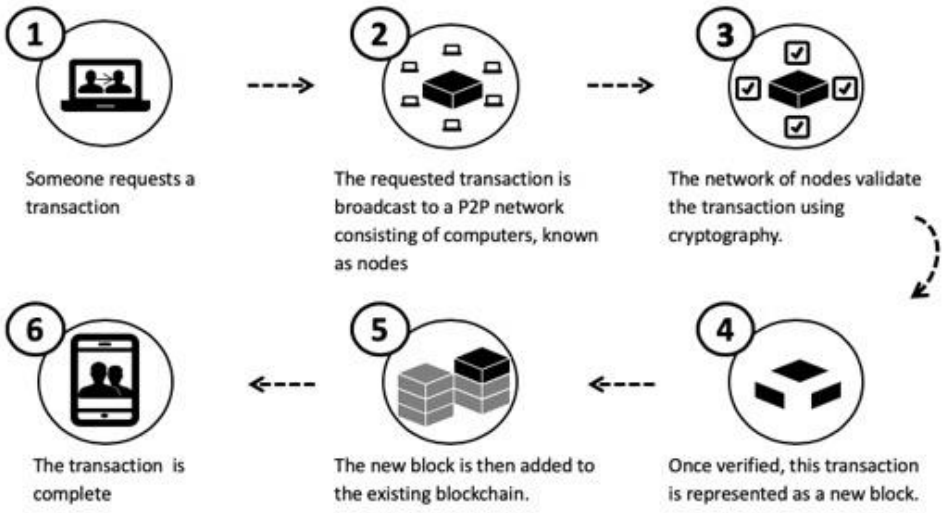
2.2.1 Blockchain Technology

Blockchain first entered our vocabulary with the birth of cryptocurrencies, such as Bitcoin, in 2009 (Nakamoto, 2008; Urquhart, 2016). A blockchain is a distributed digital ledger which is stored on multiple computers in a private or public network (Carson et al., 2018; Wang et al., 2019). It is similar to a giant spreadsheet with the features of registering all types of assets digitally and an accounting system for transacting the assets (Swan, 2015). The transactions are put into a block which are linked to the previous block as well as the following one (Wang et al., 2019). Each block is identified by its unique cryptographic "hash" (Christidis & Devetsiokiotis, 2016). The blocks create an irreversible chain and the transactions are "blocked" together (hence the word blockchain). Modifying the existing data is impossible, resulting in a tamperproof, comprehensive audit trail of the activities for the users to view. A blockchain network is a set of nodes which form a peer-to-peer network and work as the following (Christidis & Devetsiokiotis, 2016):

1. Users interact with the blockchain with private keys to sign their own transactions and public keys to access the information on the network. Signed transactions are transmitted by a user's node to its adjacent peers.
2. The neighboring peers confirm or discard the transaction depending on whether it is valid or not. Valid transactions are eventually spread across the entire network.
3. The validated transactions are collected and packaged into a timestamped block. This process is called "mining". The selected mining node broadcasts this block back to the network. The choice of mining node depends on the consensus mechanism utilized in the specific blockchain.
4. The network verifies or discards that the suggested block consists of valid transactions, and use the hash to connect it to the previous block of the chain. If it is validated, the blockchain is updated accordingly.

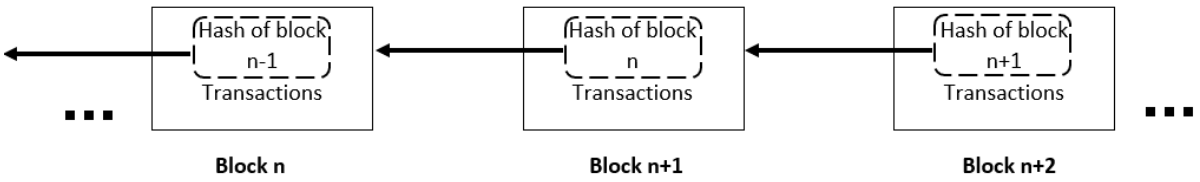
This process can be visualized in the two below illustrations (Figures 1 & 2):

Figure 1- Blockchain Transacting System



Source: own representation

Figure 2 - Cryptographic Hashes



Source: own representation. Based on Christidis and Devetsiokiotis (2016).

Instead of relying on centralized intermediaries (e.g., banks), a blockchain ecosystem allows two parties to transact directly. This makes the transactions more transparent than those provided by centralized systems (Francisco & Swanson, 2018). Transactions are thus executed without relying on explicit trust of a third party, but instead on the distributed trust based on the consensus of the network**.** There are several types of blockchains but the most prominent are public, private, and a hybrid between the two called consortium blockchain (Pilkington, 2016). A graph with main differences between the blockchain types is provided below (Table 1):

Table 1- Blockchain Types

	Public	**Hybrid**	**Private**
Overview	Fully decentralized – anybody can join and leave the blockchain	Semi-centralized by consortium of entities – entry and exit are controlled	Centralized by one entity (central authority)
Permission	Permissionless – anyone can participate with reading and writing rights	Permissioned – selected entities have writing rights	Permissioned – central authority has writing rights
Transparency	Fully transparent – transparency necessary for public verifiability	Mixed – transparency rules are decided by the consortium	Non-transparent
Privacy	Conflict between transparency and privacy	Relatively easy to control privacy	Full privacy
Security of transactions	High – immutability secured by costly mining	Depends on whether verification is costless or not	Low – change of records relatively costless
Blockchain Platform	Bitcoin, Ethereum	HyperLedger	N/A

Own representation. Source: Pilkington, (2016); Catalini & Gans, (2016); Christidis & Devetsikiotis, (2016).

For a blockchain to function properly it is essential that it has a consensus mechanism to bring consensus to the network. There are several variations, such as Proof-of-Work (Bitcoin), Proof-of-Stake (Ethereum), Byzantine Fault Tolerance and variants (HyperLedger Fabric), and Proof-of-Authority. These examples are some of the consensus mechanisms with their most typically adopted blockchain platform, for a more detailed explanation we refer the reader to Christidis and Devetsiokiotis (2016), Baliga (2017), and Sylvester (2018).

The blockchain enables the creation of decentralized currencies, intelligent assets that can be controlled over the internet (smart property), and self-executing digital contracts (smart contracts) (Kosba et al., 2016; Wright and De Filippi, 2015). The technology has mainly been used within the financial sector as a tool to manage financial transactions without the need for trusted intermediaries such as banks (Wang et al., 2019). However, it is gaining momentum within supply chains, with trust as the predominant factor driving its adoption. Wang et al. (2019) highlights that the value in supply chain management is in four areas: "extended visibility and traceability, supply chain digitalization and disintermediation, improved data security and smart contracts". Smart contracts enable companies to stipulate conditions to be met and the contract is then automatically executed when these are fulfilled. They could reduce inefficiency problems due to information asymmetries and the moral hazard following a transaction (Davidson et al., 2018).

2.2.2 Information asymmetry

Supply chain management is a complex matter since it incorporates the interests of different actors where the goals might diverge. Fiala (2004) portrays information asymmetry as a source of inefficiency in the supply chain, since it hampers mutually beneficial activities by the actors. North (1990) made the observation that "the costs of transacting arise because information is costly" and "asymmetrically held by the parties to the exchange". Dyer's (1996; 1997) extensive study on automotive companies displayed how transaction costs were decreasing when extensive interfirm information sharing was conducted. When the parties obtained better information about the counterparty, the risk of opportunistic behaviour decreased, thus leading to lower transaction costs. He takes it even further and states that "In a transaction world of perfect information, transaction costs are negligible" (Dyer, 1997). According to Nakasumi (2017), blockchain could be used to mitigate information asymmetry in supply chains and provide symmetric information to the actors involved. Reducing transaction costs is central in supply chain management and reducing information asymmetry between the actors is one way to achieve this. But questions regarding this arise as Hobbs (1996) points out "What type of information should be collected?". And how can the counterparty be trusted not to abuse the data obtained?

2.2.3 Trust

The blockchain technology enables participants to trust the system without trusting any individual participant (Werbach, 2018). The Russian proverb “trust but verify” was made famous by President Reagan during the nuclear treaty discussions between Russia and USA in the late 80’s. Similarities can be drawn with blockchain since it is basically a tool which verifies transactions in an immutable manner, removing trust from the equation. But if you verify, do you trust? The notion of trust is very intangible and Chiles and McMackin (1996) distinguishes between “real trust” and “trust-like” behaviours. In similar suit, Williamson (1993a, 1993b) warns against merging seemingly comparable behaviours into one category and labelling it “trust”. Real trust can stem from reciprocal relationships (Gouldner, 1960) and in a business environment, shared purposes and common goals between actors might enable mutually beneficial outcomes (Zajac & Olsen, 1993). This is especially true in supply chains and Francisco and Swanson (2018) highlight trust as an essential factor for supply chains to operate efficiently because of information interdependencies between organizations. Morgan and Hunt (1994) propose that when trust and commitment exist in a supply chain relationship, productivity and efficiency are enhanced. However, trusting business partners and the technology with sensitive information implies risks. What if the system is hacked or the other supply chain actors abuse the information obtained? However, trade-offs like this are always present in the business landscape and one can assume that people were sceptical of how safe the internet was regarding storing data online instead of with paper format. Trust is a key element of blockchain technology, and the distributed nature and data integrity enabled by blockchain allow members with no established relationships to transact with confidence (Francisco and Swanson, 2018). The ledger provides the manager with one version of the truth facilitating decision-making. The promises from the blockchain technology are many and yet its implementation is slow. Lippert (2007) suggests that adoption of new technology systems in a supply chain is hindered by two types of trust: interorganizational trust and trust of technology. Even after implementation, individuals do not utilize the full technological proficiency but rather use selected features necessary to complete their work (Lippert, 2007). Trust towards the technology can mainly be achieved by successful use cases and education among the employees. Lack of interorganizational trust, on the other hand, results in less commitment between the transacting partners mounting up to higher transaction costs in the form of verification, inspections and scrutiny of the transaction (Kwon and Suh, 2004).

2.2.4 Transaction Costs

Transaction costs are the costs associated with transactions and numerous scholars have examined their implications and possible ways to reduce them (Williamson, 1985, 2008; Dyer 1997; Kwon and Suh, 2004). When the transaction costs surpass the inefficiencies associated with bureaucracy within the firm, vertical integration becomes the preferred choice. Another approach is reducing the transaction costs. Several safeguards against transaction costs are highlighted previously in this paper and trust is regarded as the cheapest one, although hard to achieve (Dyer, 1997). In supply chains, reducing transaction costs and augmenting the trust and commitment in the relationship is essential in order to be successful (Bowersox et al., 2000; Kwon and Suh, 2004). Blockchain is a potential tool to enhance collaboration and trust, thus lowering the transaction costs. Korpela et al. (2017) states that today's intermediaries, such as banks, lack some fundamental functionalities which could optimize transactions further. They continue by proposing that the characteristics of blockchain could offer a solution to this problem by streamlining timestamping of transactions and tracking of the information flow. The blockchain technology offers cost-effective transmission and data security of transactions in peer-to-peer networks, and by doing so it simplifies the B2B integration (Korpela et al., 2017). Kwon and Suh (2014) found that trust embedded in a supply chain reduced the uncertainty, thus lowering transaction costs, and increased both sides' relation-specific investments. These investments enable superior performance in the long-term for the parties involved, creating mutual value (Parkhe, 1993; Dyer, 1996).

2.3 Value Creation

2.3.1 Defining Value in Strategic Management

Several academics and researchers have tried to define the term 'value' in strategic management, and a brief categorization of the major theories is necessary to introduce the concept of value in relation to supply chain and blockchain technology. Arguably, the most famous contribution comes from Resource-Based View theory (henceforth referred as RBV). As conceptualized by Peteraf (1993), organizations can be referred to as clusters of resources, with valuable resources being the true source of competitive advantage (Barney, 1991). On one

hand, a resource is defined as 'valuable' if it empowers the satisfaction of customer needs (Verdin & Williamson, 1994); on the other, it is considered as being valuable also when it allows a firm to satisfy customer demands at lower cost than its competitors. Additionally, Barney (1991) clarifies that resources that are valuable enable organizations to realize strategies that lead to more efficiency and effectiveness. The major issue with RBV theory is that it focuses mainly on internal sources of value and competitive advantage, thus partially forgetting the benefits that emerge from firms' interactions and other external forces.

Since RBV has a rather internal focus, its typical complement relies on Porter's Five Forces model, whose focus includes an industry-level analysis (Peteraf & Barney, 2003). According to Porter (2008), competition is driven by rivalry among existing competitors, threat of new entrants or substitutes and bargaining power of buyers and suppliers. The delimitations of our research constrain us from diving deeper into these mechanisms. For now, the most relevant contribution concerns the concept of value. Porter concludes his paper arguing that only a real understanding of the five forces that shape competition would allow companies and management to better focus their strategy in order to capture "true economic value" (Porter, 2008). This is a fundamental concept – value capture – and some clarifications are beneficial for the pursuance of this chapter. Through a comprehensive literature review upon the concepts of value in strategic management, Bowman & Ambrosini (2000) distinguish between value creation and value capture. The first is typically determined by organizational resources, thus linking back to RBV theoretical model. Value capture, instead, is shaped by the "perceived power relationship" among the value chain actors – namely buyers and customers. Therefore, this latter concept clearly relates to the already mentioned Porter's framework, acknowledging bargaining power along the supply chain as the major source of value for organizations. Value capture has also been analysed by Sawhney, Wolcott & Arroniz (2006). According to them, value capture is one of 12 dimensions of business innovation and it refers to the process companies should follow in order to recapture the value they create. Even in this case, the major source of value capture comes from the external environment, by better interacting with the firm's partners.

Lastly, in order to clarify which of the different approaches will be of guidance throughout the rest of the research, this paper addresses the term "value" as conceptualized by Peteraf & Barney (2003). According to them, value must include both sides of the equation and it is defined as "the difference between perceived benefits, or customer willingness-to-pay, on the

one hand, and economic costs on the other" (Peteraf & Barney, 2003, p. 314). This conceptualization assigns great importance to the bargaining power among the actors, since producers and customers will retain a share of the value in terms of producer surplus and customer surplus. However, the most relevant contribution for this research comes from the abovementioned definition of value, as it recognizes the importance of the marketing side (perceived benefits) as well as the efficiency side (economic costs) of the value creation.

2.3.2 Value Chain

Brandenburger & Stuart (1996) - other exponents of RBV theory - recognize the importance of value chain players. Nonetheless, their definition of "total value" is still affected by the traditional view on cost analysis, that refers to value with the static concept of 'value added'. According to Brandenburger & Stuart (1996), value added is synonym of value appropriation and the total value is given by the sum of the values secured by each member involved in a transaction. In contrast with this traditional concept of value added, the value chain analysis described by Shank & Govindarajan (2008) offers an interesting perspective in the field of strategic cost management. The authors point out that the value added approach can result in a misconception mainly because it does not consider the linkages between organizations and their suppliers and customers, as well as the synergies between raw materials and other cost inputs. To this extent, Shank and Govindarajan (2008) provide us with a new methodology for constructing the value chain. Some comparisons can be drawn with Porter's 'Value Chain' model. Both frameworks assign costs and revenues to each activity, in order to investigate the cost and revenue drivers. However, in Porter's model the focus is still on the value added, defined as the mere profit margin generated by each activity, with the competitive advantage being achieved by ensuring either lower costs or higher prices than competing organizations (Porter, 1985). Shank & Govindarajan (2008) argue that competitive advantage can be effectively generated only if the entire value chain is considered, referring to it as the "entire set of linked activities from raw material suppliers to end-use customers". They also go one step beyond Porter when they affirm that the competitive advantage is enhanced by the strategic fit of the firm's activities with buyers and suppliers' activities. This concept has been widely analyzed by both Porter's and RBV theorists, but is important to draw the reader's attention

towards the effects of information sharing across the value chain and how upstream and downstream linkages can enhance this flow.

In the rest of the paper, the terms value chain and supply chain will be used as synonyms. However, it's beneficial to clarify that the paper addresses the term "supply chain" or "value chain" as being representative of the "linked activities from raw material suppliers to end-use customers" (Shank & Govindarajan, 2008).

2.3.3 Information Sharing

In every supply chain there are typically tangible, physical flows consisting of raw materials, work-in-process inventories and end products as well as intangible flows of financial data and other relevant information. Sahin & Robinson (2002) argue that having effective and efficient flows lies in supply chain coordination and integration among the different entities. And a supply chain is entirely coordinated only when there is a strong alignment by all the involved actors towards pursuing mutual objectives. When it comes to information sharing and the issues behind supply chain coordination, the most undisputed contribution comes from Forrester (1958). In his theory of 'Industrial Dynamics', the famous researcher draws the attention on how delays, fluctuations and exaggerations in the information flow can negatively influence supply chain operations, mostly in the form of inventories and production rates. By analysing a typical supply chain – producer, warehouse, distributor and retailer – Forrester (1958) shows the effects of the abovementioned issues. This phenomenon has then become widely known as the 'bullwhip effect' or 'Forrester effect'. In short, because of overstated orders made during purchases and replenishments, information flows from producer to distributor to retailer causing distorted and excessed demand in the actual quantity. This effect is amplified stage after stage in the supply chain, thus resulting in a bullwhip effect. And as highlighted by Fiala (2004), information asymmetry plays a vital role in fostering the bullwhip effect along supply chains. Common measures to reduce this effect relate to Japanese Just-in-time (JIT) production systems and Total Quality Management (TQM) procedures. Additionally, Information Technology has radically changed the way data are gathered and shared across the supply chain and it has perhaps rendered some of the challenges highlighted by Forrester obsolete. Nonetheless, problems related to the bullwhip effect and widely linked to inventory management are still a major issue in supply chain management.

2.4 Value Creation and Blockchain

2.4.1 Decentralized Information

In the last paragraph of the previous chapter, the importance of sharing data in the supply chain has been highlighted. According to Lee & Whang (1999), and as acknowledged by Sahin & Robinson (2002), supply chain coordination can be achieved through either centralized or decentralized decision-making mechanisms. Both systems have their own benefits and drawbacks. Although lacking the typical coordination of centralized systems, the presence of local knowledge ensures reliable data in decentralized mechanisms (Sahin & Robinson, 2002). When describing the possible coordination structures for decision-making systems, Anand & Mendelson (1997) distinguish between centralized, decentralized, fully distributed and structures without any information shared. Among these four typologies, the authors point out that fully distributed systems are the best solution, ensuring that all data have been shared across the involved actors and that local knowledge helps each party in making the best decision.

As previously explained, blockchain can be defined as a distributed ledger shared across a computing network. Because each computer node in the ecosystem detains a copy of the ledger, there cannot be a single point of breakdown. Every data is mathematically encrypted and will be part of the chain as a new block (Carson et al., 2018). A core aspect of the technology leans on the fact that thanks to various consensus mechanisms there is no need for a central authority that validates the transactions, thus ensuring a decentralized and distributed system, similar to the one theorized by Anand & Mendelson more than two decades ago.

2.4.2 Sources of Value Creation in Blockchain

As demonstrated, the concept of value embraces both the cost side as well as the premium side, in the form of consumers' willingness-to-pay. But where does this premium come from? The rest of the chapter will try to answer this question by reviewing relevant literature in the field of supply chain management and blockchain technology. In doing so, the major challenges of (food) supply chains as well as how blockchain fits in this environment will be touched upon.

2.4.3 Traceability

Traceability involves tracking products end-to-end in the supply chain. The first definition that is relevant for this paper comes from the quality management and assurance standard ISO 8402:1994: “traceability is the ability to trace the history, application or location of an entity, by means of recorded identifications” (Aung & Chang, 2014, p. 173). Following this quote, Moe (1998) argues that traceability needs to incorporate two distinct aspects – product and data. And when it comes to food supply chains, where products are highly altered along their lifecycle, keeping track of all the information plays an essential role. By focusing on the dairy industry, Manikas & Manos (2009) developed a model aimed at realizing better traceability of dairy products. They found that an efficient traceability system must ensure the collection and storage of all the relevant data in each phase of the food supply chain. This paper is beneficial to conceptualize the status quo of substantive literature upon traceability management in the dairy industry. Manikas & Manos (2009) proposed an online central database, in order to ensure high efficiency and monitoring standards for the new traceability platform. Thus, their contribution offers a strong link to the new boundaries of traceability management that might be ensured with blockchain technology. An interesting contribution is also that of Golan et al. (2004). Even if their work was focused on US firms, their findings can be generalized, as done by Aung & Chang (2014). According to Golan et al. (2004), enterprises use traceability systems for three main purposes: better supply management; easier traceback for food safety and quality; differentiation with products with different attributes. The benefits associated with these goals are lower distribution costs, reduced recall expenses and expanded sales of products with attributes that are difficult to detect. Although several authors describe traceability in food supply chain based on IoT technologies – see Li et al. (2010) for a detailed overview of RFID systems and their applicability for tracking products – blockchain closes the gap and adds trust to the system. With the use of blockchain, every single data is encrypted and verified without the need for a central authority. Although the literature of blockchain in supply chain is still in its infancy, Tian (2018) offers a relevant academic contribution to the concept. The main benefit of blockchain in food supply chain is that it allows the storage of data in a “shared and transparent system for all the members along the supply chain” (Tian, 2018, p. 14), going beyond the traditional opaque information system that usually gather product information.

2.4.4 Transparency

Closely correlated to the concept of traceability is that of transparency, as argued by Skilton & Robinson (2009). However, according to them, the relationship between traceability and supply chain transparency is not strictly bidirectional. Whereas having more transparent information might lead to enhanced traceability, increased traceability might not lead to enhanced transparency in the case of a supply chain made of few participants with loose connections (Skilton & Robinson, 2009). The following section aims at categorizing the concept of transparency in the context of food supply chain and blockchain technology.

Paraphrasing Beulens et al. (2004, p. 482), transparency in a supply chain ecosystem can be defined as the degree to which all the network's stakeholders have a shared comprehension of, and access to, product and process related data that they demand, without "loss, noise, delay and distortion". Linking transparency to value creation, Prahalad & Ramaswamy (2004) argue that firms have always considered value as an internal source, ignoring to exploit the potential that comes from interacting with customers. In drawing the attention to the consumer side, Prahalad & Ramaswamy (2004) assign a special role to transparency. According to them, value creation cannot forgo customers, and customers have been expressing a growing need for transparency, for a better access to product information. By introducing the concept of "operational transparency" as the voluntary design of windows in and out of companies' operations, Buell (2019) argues that value can be created because customers better understand the effort and work that is behind the scene. Although his work focuses mainly on companies and services rather than products and data information, an interesting concept is drawn towards the conclusion: the fact that transparency builds trust only when it is voluntarily provided. If embedded in the system due to regulatory or investor pressures, its value decreases steadily because it misses the opportunity of instilling trust (Buell, 2019). When it comes to transparency and trust in food supply chains, food safety plays a central role in ensuring that companies recapture the value generated along the supply chain. As Beulens et al. (2004) already affirmed more than a decade ago, consumers want the food they consume to be safe and trustworthy, asking for availability of more reliable information. As previously mentioned, blockchain aims to solve transparency and trust-related issues in the food supply chain. According to Kshetri (2018), blockchain ensures the auditability of all the transactions in the network, thus creating a strong incentive for gaining the trust of the interested parties. And thanks to blockchain, consumers can finally know if the food they are consuming is "right and authentic" (Kshetri, 2018).

2.5 Chapter Summary and Theoretical Framework

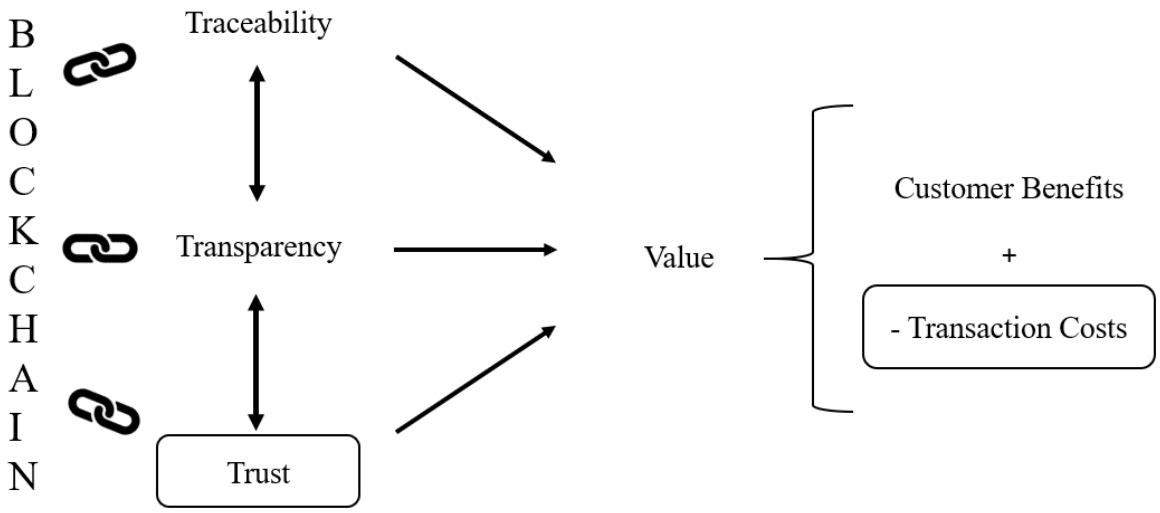
This chapter's aim is to shed lights on possible strategic implications of blockchain in the supply chain by reviewing the most relevant literature in the field of TCE and Value Creation. Since blockchain is a relatively new technology and the applications in the supply chain field initiated just a couple of years ago, the connections between transaction costs, transparency and trust in the academia are yet in their infancy. By combining traditional literature with articles treating the blockchain technology, it is possible to create the foundation on which we construct our theoretical framework. The potential implications of the blockchain on supply chains are many and only the most relevant have been included in order to produce a tangible, yet comprehensive, framework. The traceability, transparency, and trust aspects were the ones we found most overlapping and relevant in the supply chain and blockchain literature. As argued in detail in this chapter, blockchain can play an important role in the supply chain, affecting traceability, transparency and trust. Traceability and transparency are closely interrelated and they increase trust. Moreover, trust usually leads to a more transparent relationship in a supply chain, lowering uncertainty and thus reducing the transaction costs. All these factors enhance value creation opportunities in the form of reduced costs or increased customer benefits[1]. In particular, based on these theoretical premises, we believe that this technology will strengthen these linkages, ensuring trust and reducing the transaction costs. Therefore, trust and transaction costs are believed to play a more important role than the other factors. Since we are not sure whether a factor such as transparency has a specific influence on both the sides of the value, the framework has been designed in order to emphasize the influence exerted by the determinants on the value in a more comprehensive way. Hopefully, testing the framework in

[1] "Customer benefits" and "consumer benefits" will be used interchangeably throughout this paper.

a specific context will provide us with further, valuable insights that will unveil if all the determinants affect both the cost and the benefit side of value.

Stemming from the above theoretical concepts is our proposed framework, which aims at better visualizing the strategic implications of blockchain in supply chain, integrating the factors we find most relevant:

Figure 3 - Theoretical Framework



Source: own representation

3 Methodology

In this chapter, the methodology underlying the paper will be presented. The research approach and design considerations, as well as other methodological choices, will be illustrated. This will be followed by a reflection on the research process and chosen industry. The last part of the chapter will treat the data collection aspect ending with reliability and validity concerns.

3.1 Research Approach

When conducting a research, it is essential to convey the worldview of the researchers because this will shape the paper, at least subconsciously. Creswell (2014) highlights post positivism, constructivism, transformative, and pragmatism as the major worldviews, widely discussed in the literature. Our main approach and set of beliefs that will guide our action are reflected by the constructivism view. We believe that the realities can differ depending on the context, and individuals interpret events differently depending on their history. Our ambition is trying to understand contemporary issues in the supply chain and derive how the blockchain could be potentially utilized to solve them. Due to individuals developing subjective meanings, the complexity increases but the goal of the researcher should be to rely on the interviewed respondents' views of the situation (Creswell, 2014). Therefore, it is imperative for the researchers to develop open-ended questions in order to enable the respondents to express their viewpoint as unbiased as possible. By conveying our assumptions to the reader, our intentions and findings can be understood with less room of confusion. Additionally, it must be stated that the researchers are permeated by pragmatism and thus this worldview will also influence the paper.

Despite the fact that we have constructed our framework based on an extensive review of literature, our intent is not to convey that there is one truth regarding this issue and we will avoid developing hypotheses to test. Instead, we put our emphasis on a complex technology's benefits and downsides and the framework is merely a tool to better guide our course of action

trying to understand the technology. This interpretive research style involves a dialogical process between empirical phenomenon and the theory. It is founded on an interpretive epistemology and is associated with abductive reasoning (Bell, Bryman & Harley, 2019). Abduction has grown in popularity in business research and is proposed as a mode of reasoning to overcome the limitations associated with inductive and deductive positions. In other words, abductive reasoning is a mix between deductive and inductive approaches. The starting point of abductive reasoning is a puzzle which may arise when "researchers encounter empirical phenomena which existing theory cannot account for" (Bell, Bryman & Harley, 2019, p. 24). By identifying conditions and factors regarding the topic, abductive reasoning tries to make the phenomenon less puzzling (Mantere & Ketokivi, 2013). Thus, an abductive inquiry was taken in order to use a cyclical approach when examining the technology in conjunction with theory and empirical findings. Deriving from this, it became clear that a qualitative approach was demanded in order to fulfil the purpose of our research.

3.2 Research Design

The research question in this paper aims to examine a specific nascent technology through a qualitative approach. It is imperative that the research design is constructed to facilitate the data collection needed to answer the question (Easterby-Smith, Thorpe and Jackson, 2015). A qualitative approach aims to explore and understand the meaning individuals ascribe to an issue (Creswell, 2014). This enables the researchers to examine and interpret the data collected in a flexible way while honouring the complexity of the situation. Since the ambition of the paper is to examine blockchain's impact on the supply chain, this paper will use a single case study, specific to dairy industry, embedded in a more general description of blockchain and supply chain in related industries. A case study is a common type of qualitative inquiry, which provides the researchers an in-depth knowledge of the case in its particular context (Hyde, 2000; Esterby-Smith, Thorpe & Jackson, 2015). Qualitative research approaches are often criticized for their limited ability to generalize the findings and the case study inquiry is no exception (Yin, 2013a). However, even though a quantitative approach is better suited for this purpose, a case study can form the foundation for theory building and inspire deductive research (Eisenhardt and Graebner, 2007). Additionally, blockchain is such a novel technology that its implementations

are still in infancy, particularly in the supply chain, thus making a quantitative analysis rather difficult to operationalize**.** The case study design is often distinguished into single, multiple, holistic or embedded case studies (Yin, 2013a). To this extent, our approach falls in between the holistic and the embedded case type. To find a better classification we can then refer to Creswell (2014). Based on his work, our design can then be categorized as being emergent and having a holistic account. On one hand, an emergent design means that part of the process can change during the data collection process; on the other, a holistic account refers to the fact that the qualitative researchers try to develop a broad and complex picture of the problem under investigation (Creswell, 2014). For these reasons, we felt that having a single case study embedded in a broader context analyzed through different primary sources was the best approach in order to fulfil our research purpose. The downside of this approach was the limited timeframe, since case studies are often characterized by examining the unit of analysis over time (Esterby-Smith, Thorpe & Jackson, 2015). In order to cope with time and resource constraints, we defined boundaries and then narrowed the scope of the study to delimit the amount of data gathered. As stated by Yin (2013a), analytic generalization is deemed to be highly important when conducting qualitative studies. Yin (2013b) states that it is then possible to utilize the analytic generalization in order to generalize the findings from a specific case study and then apply it to other similar situations. We believe that the findings from the dairy industry will also be applicable to other food supply chains, and ultimately to other supply chains.

3.2.1 Reflection on the Research Process

As anticipated, our approach can be described as an emergent design (Creswell, 2014). In the beginning of the research our ambition exceeded the practical reality constrained by time and resources. Initially, the ambition was to examine an entire supply chain using the blockchain technology, in order to derive the benefits gained compared to other ERP systems. However, this deemed to be a difficult task due to scarcity of entire supply chains using the technology and lower response rate from organizations than anticipated. During the research process we therefore revised our unit of analysis; although we looked at the implications of blockchain for the entire dairy supply chain, the research was conducted mainly from the perspective of the processors – as it is testified by our main case study.

3.3 Choice of Blockchain and Industry

Since our research includes the examination of firms in a specific industry, here we want to elaborate on the premises we made our selection on. As mentioned in the introduction, the food industry is undergoing rapid changes. The growing awareness of consumers has drawn our attention on the themes of transparency and trust. These and other issues of today's supply chains could find an initial answer in the adoption of blockchain technology. However, due to its novelty and infancy in supply chain applications, we decided to restrict the selection to dairy supply chain, since this industry offered us some promising use cases, with Arla Finland being the most interesting one in the context of Western Europe.

3.4 Data Collection Method

As mentioned by Creswell (2014), the choice of a qualitative approach allows the writers to better interact with the different participants in order to learn about the problem and to direct the research to gather that information. Of the five possibilities recommended by Creswell under qualitative designs – narrative, phenomenology, ethnography, case study and grounded theory – we chose the case study approach. In line with this choice, multiple data methods have been used to test our theoretical hypotheses and help us in gathering different types of answers. And as highlighted in Yin (2013a), multiple data sources are said to enhance data reliability.

The data collection procedure entailed the gathering of both secondary data and primary data from various sources, with the aim of fulfilling the research question. As suggested by Creswell (2014), qualitative studies need to "purposefully select" the data sources - being them individuals or documents – that will help the writers in answering the research question. In gathering the relevant data, we first looked into major consulting firms' reports that addressed the themes of blockchain and supply chain as well as peer-reviewed articles that focused on supply chain challenges. After reviewing more than a hundred of documents, we had a clearer view of our topic and we started gathering data from academic journals that addressed the themes of TCE as well as value creation, as these emerged as being the most relevant areas in which to focus our literature review in order to design the research question. While reviewing

the literature, a close eye was kept on practical sources regarding blockchain in supply chain. As mentioned in the introduction of this paper, blockchain applications are still in their infancy, thus we felt the necessity of understanding the state of the art of the technology and its current use cases in order to better fulfil the research purpose. To this extent, we interviewed several experts in the field of food supply chain as well as blockchain technology. These interviews served to construct the right background to our main case study, as we then had a better understanding of the topic in order to deepen into dairy supply chain.

When collecting the different literature, academic journals and peer-reviewed articles have been carefully checked and selected. The primary database used to access these sources was Google Scholar, as it offers a broad selection of peer-reviewed articles by collecting content from the free web as well as publishers' and scientific societies (Lewandowski, 2015). Beyond Google Scholar, the sources were accessed and checked via multiple databases that gather academic articles and journals, such as Business Source Complete, EBSCO, JSTOR and Scopus. Additionally, the amount of citations of each document was carefully considered, as this can be indicative of the reliability of the source (Easterby-Smith, Thorpe & Jackson, 2015).

3.4.1 Interviews

As mentioned before, qualitative studies cannot achieve the same level of generalization given by quantitative surveys (Bell, Bryman & Harley, 2019). However, qualitative interviews give the opportunity to elicit relevant opinions and perspectives from the participants (Creswell, 2014). When participants cannot be directly observed, interviews in the form of either audio or video result to be very useful, enabling the researcher to control the direction of the discussion (Creswell, 2014). Nonetheless, researcher's presence might bias the respondent's argumentation. Therefore, it is crucial to ask open questions that leave space to further points of view. Amongst the various interview formats, semi-structured interviews result as being the most suitable typology for this thesis. This type of interviews enables the pursuance of some guided structure without hindering interaction among the participants (Bell, Bryman & Harley, 2019). Because of our relatively limited knowledge of food supply chains and blockchain, structured interviews were avoided. Moreover, the respondents showed considerable interest towards our research; thus, semi-structured interview were the best format, enabling the creation of a mutually beneficial dialogue. Unstructured interviews were also avoided, since

the purpose of this paper was to find answers to our research question, guided by our theoretical framework.

3.4.2 Interview Preparations

In order to conduct a proper case study, some criteria for choosing the respondents were set up. The respondents had to have knowledge in the dairy supply chain industry and in the blockchain field. Participants with knowledge and expertise that was broader than the above-mentioned criteria were also selected and used as background interviews in order to better analyse the case study. To this extent, relevant insights came from experts in the field of blockchain that were not necessarily involved in dairy, but rather with other Food and Beverage companies. This allows us to get a holistic and impartial perspective on the use of blockchain in dairy supply chain.

All the respondents were contacted via email, phone or LinkedIn. Snowball sampling technique was used to reach other people as respondents were asked to refer us to other relevant contacts inside and outside of their organizations (Easterby-Smith, Thorpe & Jackson, 2015).

3.4.3 Design of Interview Guide

A preliminary interview guide was elaborated before conducting any interview. This guided us through the various interviews and helped to maintain the focus on our theoretical framework in order to address the research question. Although led by this guidance, we tried not to bias the respondents by asking open questions, thus enhancing more flexibility in their argumentation (Easterby-Smith, Thorpe & Jackson, 2015). Since our standard interview guide aimed at covering all the aspects we intended to analyse, we then adjusted the questions depending on the respondent's historical background as well as current professional role. This was also an iterative process during the interview itself. To be more specific, if the respondent were dairy experts with no knowledge about blockchain applications, the discussion was led towards more general aspects such as decentralized supply chains or food transparency concerns. The interview guide can be found in Appendix A.

3.4.4 Conducting the Interviews

The interviews were conducted following a remote process, that means interviewing the respondents while being distant, through phone, video (Skype) or email. Although face-to-face interviews can enhance a more natural interaction between the interviewers and the respondents, remote interviewing can provide both the actors with greater flexibility in terms of not being constrained by time and space availabilities (Easterby-Smith, Thorpe & Jackson, 2015). Prior to the start of any of the interviews, respondents were asked about giving their consent to record the interview, thus offering us the opportunity to listen back and transcribe the interview afterwards. Although Easterby-Smith, Thorpe and Jackson (2015) argue that recording might be an obstacle in the interaction with the respondents, this procedure was necessary in order to increase the validity of our data collection. When conducting the interviews, both the researchers were collecting notes and participating in the discussion in a simultaneous way. Whereas some researchers prefer to divide the roles, with one person asking question and one taking notes, having a simultaneous approach enables the opportunity of viewing the same topic from multiple perspectives (Eisenhardt, 1989).

3.4.5 Respondents

In total, 11 interviews have been conducted, with the participation of 12 different respondents (see Table 2). As for the single case study in question – Arla – a single interview has been conducted with each of the three people responsible for the project, Tomi Sirén (Head of Digital at Arla Finland), Esa Peltonen (Co-Founder at Truly Agency) and Jan Borgelin (CEO at Empirica). In addition, Kimmo Halunen, a cybersecurity researcher that was interviewed by ARLA prior to the project, has also been interviewed by us. This audience offered us a holistic overview of the project. Furthermore, the other respondents came from a broad range of organizations, ensuring the right expertise in the dairy industry as well as blockchain technology. This should increase the external validity as well as the generalization of the findings. Whereas the respondents did not agree upon the use of their name and/or their organization, anonymization was necessary in order to respect their privacy. Although this is thought to reduce the reliability of the data, this approach is sometimes necessary in order to ensure the right confidentiality (Sieber & Tolich, 2013).

Table 2 - Respondents

Respondent	**Current role**	**Organization**	**Time (minutes)**	**Via**
R. Baars	Researcher	Van Hall University	55:00 + 57:00	Skype Video
J. Borgelin	CEO	Empirica	63:00	Skype Audio
A. Voje	Head of Communication	OriginTrail	30:00	Skype Audio
H. Beck	Digital Enterprise - Industry Manager	Siemens	59:00	Internal Video Circuit
T. Sirén	Head of Digital	ARLA Finland	64:00	Skype Audio
J.B. & M. E.	N/A	Supplier of Processing Solutions	55:00	Internal Video Circuit
K. Halunen	Researcher	VTT Technical Research Centre of Finland	57:00	Skype Audio
F. Jansson	Management Consultant	PwC	40:00	Phone
E. Peltonen	Growth Strategist and Co-Founder	Truly Agency	64:00	Skype Audio
J. Graubins & R. Arandel	Senior Business Analysts	EU Blockchain Forum – Verum Capital	29:00	Skype Audio
		Total	573:00	

3.5 Reliability and Validity Issues

The validation of the findings is a process that run throughout the entire research (Creswell, 2014). When it comes to qualitative studies, some concepts must be addressed in order to deliver a solid paper, that can be replicable by future practitioners. The most important concepts for this research regards reliability and validity. Reliability is usually associated with the concept of stability (Creswell, 2014). Therefore, it is commonly acknowledged that quantitative studies can guarantee greater reliability compared to qualitative approaches. Nonetheless, we tried to ensure the greatest possible reliability in our research design, following some of the recommendations offered by Riege (2003). Amongst them, examining multiple data sources enables a greater degree of data reliability, as also acknowledged by Yin (2013a).

If qualitative studies may lack reliability, a different argument arises for validity concerns. As argued by Creswell & Miller (2000), qualitative studies offer stronger validity because they aim at determining the accuracy of the findings from multiple perspectives – researcher, participants and readers. Moreover, validity is increased when gathering data from different sources (Creswell, 2014). This approach was followed throughout the data collection procedure, thus strengthening the construct validity (Riege, 2003). We also believe that our research design offers some degree of external validity. External validity can be defined as how "far the conclusion can be generalized across other types of person, settings and times" (Easterby-Smith, Thorpe & Jackson 2015, p.73). Although the respondents were mainly representative of the dairy industry, having interviewed experts within the blockchain world enabled us to draw broader conclusions regarding blockchain in supply chain, thus possibly replicating this study with at least a focus on other food supply chains. Therefore, although case studies often lack wide generalizability, external validity should bring some degree of generalizability to this research. Lastly, when considering these issues, a strong attention has been given in gathering similar findings in the substantive literature described in the previous chapter. This results in higher internal validity as well as greater conceptual level (Eisenhardt, 1989).

3.6 Chapter Summary

This chapter provides a comprehensive description of the process followed when gathering data as well as theories underlying this paper. The selected approach was a qualitative design in the form of a single embedded case study, in order to better analyse the issues of supply chain and the applicability of blockchain in this context. The research question has guided us in the choice of literature as well as primary and secondary data. The combination of interviews and secondary data from various sources was carried out to increase the analytic generalizability, thus benefitting future research in the field.

4 Empirical findings

This section is dedicated to present the findings of this paper. This will be done by presenting the secondary data as well as the primary data in a simultaneous way. As argued in the methodology, the integration of both the sources enables a greater data credibility and would offer a broader picture of the matter. Before focusing on the pure findings gathered during this research process, some key facts and numbers about the dairy industry in Western Europe will be presented, thus helping the reader familiarizing with the context.

4.1 From Farm to Fork – An Overview

Western Europe offers a stable and mature landscape in the dairy industry. As a matter of fact, the region is second only to "Australasia" for the *per capita expenditure* on dairy products, reaching USD 227 per year (Passport, 2017). Sales between 2012 and 2017 registered a continuing decline that was mainly due to a reduction in value sales driven by four of the biggest markets – France, Italy, Spain and UK – while Germany registered a growth in its figures (Passport, 2017). And in total, these five major countries account for almost 62% of the dairy market value of the entire Europe in 2017 (MarketLine, 2018). Despite these premises, the region is expected to register a slight growth over the 2018-2022 period, approaching the levels reached in 2012 (Passport, 2017). This growth is driven by innovation, stable economies and broader product range.

Beyond this financial data, it is important to clarify what can be grouped under the term "dairy" and which actors characterize the supply chain. According to the World Bank (1998, p. 295), the dairy market involves the processing of "raw milk into products such as consumer milk,

butter, cheese, yogurt, condensed milk, dried milk (milk powder), and ice cream"[2]. Recently, the industry has been facing the rise of new products in the form of lactose-free products, soy-milk, almond-milk as well as other plant-based alternatives. For instance, in the UK market plant-based milk sales have grown by one third between 2015 and 2017 – according to market researchers Mintel (Stokel-Walker, 2018).

As for the supply chain, it is beneficial for the reader to know that this paper addresses the dairy supply chain as being representative of five main steps – namely farming, processing, distributing, retailing and consuming. Although the recent technological developments and the abolition of the milk quotas have benefitted the farmers across Europe, farmers have been experiencing the worst economic situation among all the supply chain actors. To this extent, two of the interviewees – Baars and Halunen – confirmed that farmers in countries such as The Netherlands and Finland, two of the most advanced European markets, barely make any profit by selling their milk to the processing companies. As a potential countermove by the farmers, Baars emphasized that direct sales from farmers to end-consumers has experienced an enormous augmentation during the past decade in the Netherlands. This view is reinforced by a report of the European Parliament, which states that shorter food supply chains with a minimum of intermediaries have flourished in all EU countries. On average, 15% of EU farms sell more than half of their production directly to consumers[3] (Augére-Granier, 2016). Direct sales and shorter supply chains have advantages such as a fairer price to farmers and reduced environmental impact. Low prices to farmers, together with the willingness to scale and reach wider markets, has led to the formation of big cooperatives of farmers, with two famous cases being Arla and FrieslandCampina. These are also two of the major processing companies that operate across Europe (and beyond). The dairy industry in Europe can be defined as rather

[2] Although the document is no longer in use by the World Bank, they still reference to it as the best source for classifying the dairy industry, as mentioned in later documents.

[3] However, the majority of these farms are small.

fragmented, with private label brands dominating the scene, reaching more than 30% of the dairy sales in Europe (Passport, 2017). Other major brands include Danone, Lactalis, and Muller. Besides Danone, that has been able to reach a profit margin around 8-10% between the last two years (MarketLine, 2018), all the other big producers have a profit margin that fluctuates between 1 and 3% (Arla Foods, 2019; Royal FrieslandCampina N. V., 2019; Savencia Fromage & Dairy, 2019). This low marginality of the upstream actors, together with the strong market share of private labels, should lead the reader to the conclusion that the power in the dairy supply chain resides in the hands of the retailers. This argument is supported by the opinion of Baars. During the interview, the Dutch professor highlights how the retailers can really put pressure on the processors, by choosing which products will reach their shelves and which will be rejected. In general, traditional supermarkets and hypermarkets still lead the retail category in terms of sales across Western Europe, with the only exception being Germany and Norway, in which the market share is dominated by discounters (Passport, 2017). Beyond the growth of the discounters, incumbent supermarkets have also been facing the rise of online grocery for food products. The growth of this new sales channel has been led by Amazon Fresh and Ocado (Passport, 2017). This demand for convenience and for on-demand purchases has been driven by consumers in different countries, with UK and France leading the way (Passport, 2017).

Consumers are not only demanding more convenient purchases; they are also driving the quest for a more transparent supply chain. For this reason, the following separate section is dedicated to them.

4.1.1 Consumers

At the time Fairtrade emerged, using a product label to state something about standards in a supply chain was revolutionary, but today it is routine (van Vark, 2016). The Ecolabel Index currently tracks 463 certifications in 199 countries (Ecolabel, 2019). Promising higher standards and transparency in global supply chains was a way to give consumers a vehicle to choose more sustainable and fair products. However, with the huge surge of certifications and labels, consumers get confused and uncertain on what to trust. Nowadays, consumers demand increased transparency in order to make informed purchase decisions regarding the product in terms of environmental or welfare reasons (Hancock, 2017). This demand for sustainable

products is especially fuelled by the young consumers, such as millennials and Generation Z, who are increasingly conscious about the purchases they make. A recent report from Label Insight (2018) highlighted that almost all consumers (93%) find it important that brands provide detailed information about the supply chain and how the product is made. In addition, the number of shoppers who state they would switch brand from what they usually buy, to another brand that provides more transparency, has increased from 39% in 2016 to 74% in 2018. The movement towards increased transparency has shifted from solely early adopters to the incumbent firms due to the success of the early adopters (Label Insight, 2018). This trend is also present in the dairy industry and due to a number of scandals in recent time, firms must take measures to ensure the security of their supply chains to maintain customers' trust (Deloitte, 2017). However, Baars highlights the importance of reading consumer reports with care:

"…there is a difference between asking people are you prepared to pay more compared to people who are standing in the supermarket and really doing it."

He believes the number of people actually willing to pay more for a transparent product is much lower and at the range of 10-15%. These critical customers are very conscious about what they buy, but the majority continue focusing mainly on the price. His concerns are reflected in the vast array of consumer reports where the range of consumers willing to pay more diverge a lot (Response media, 2017; Label Insight, 2018; Siemens, 2018). Nevertheless, the trend of increasing importance of transparency is echoed in all the reports and there is no doubt that consumers today are more conscious than before. Patrick Moorhead, CMO at Label Insight, says that: "*The need for transparency is driving dramatic shifts in the food retail industry that impact how business as usual is done for both brands and retailers."* Additionally, he states that consumer awareness is increasingly reflected in their buying patterns (Shoup, 2018). Certification standards, such as Fairtrade, have contributed to making supply chains more transparent over the past decades, but more companies are today moving away from this by initiating their own in-house schemes (van Vark, 2016; Worsley, 2018). Sainsbury, Starbucks, and Unilever are some examples of companies developing their own sustainability schemes and consumers are fearing that this will decrease the transparency and is simply an excuse to achieve higher profits (Worsley, 2018). But tracking the provenance of products is a complex and costly

matter in global supply chains and even when managing smaller ones, it might be hard to convince the customers of the authenticity of the information provided. Jan highlighted that current regulations in the majority of supply chains mandate only a moderate level of traceability – one step back (company's suppliers) and one step forward (company's customers) – but consumers' demand for more transparency is affecting this, making end-to-end traceability a necessity. Deloitte's dairy industry report (2017) highlights that new technologies, such as blockchain, could be a potential tool to track how the product is made.

4.2 Decentralized Supply Chain

Borgelin claims that one problem with certifications is that different products can achieve the same label even when the level of sustainability differ immensely. Categorizing products with labels implies advantages for some companies and disadvantages for others. Additionally, it is not enough with a label stating that the product is, for example, ecological. Borgelin:

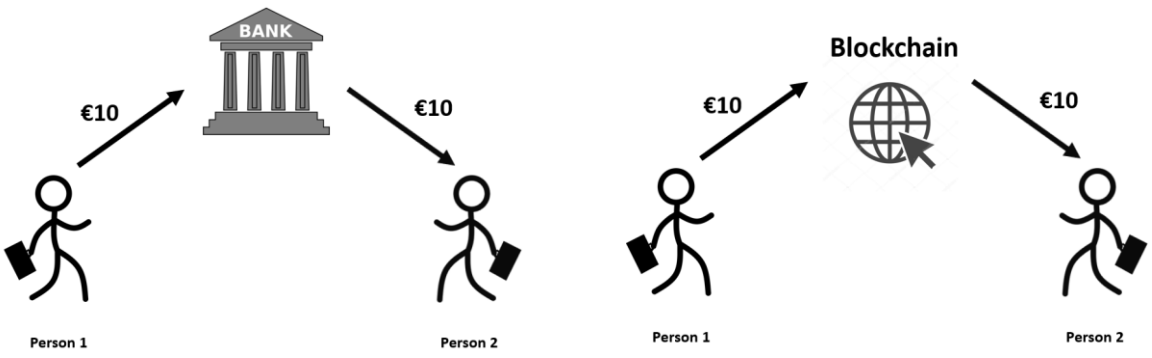
"...something that certifies the origin, because the consumers want to see more like ok this sustainable production at the beginning, but then what about the processing?"

The consumers today want more and more information and certifications is an inefficient way to cover this broad spectrum of information. Traceability and transparency throughout the entire supply chain become imperative in order to convey the reality to the consumer. It is not enough to state that the product is sustainable upstream, the consumers care about the entire supply chain from farm to fork. OriginTrail collaborated with a dairy company, Celeia**,** in order to create a new traceability solution. They wanted to project to the consumers that the milk was locally produced by enabling the customers to scan a barcode to see exactly where the milk's journey to the store. But questions arose regarding how to trust the quality of the data. Voje:

"What if something went wrong and the company could just change the data in the system? That is when we discovered blockchain as a possible solution to ensure the immutability of the data."

Blockchain, and the concept of decentralization, appeared to be a potential solution. By putting the data on the blockchain the risk of contamination of data was reduced drastically and the data could potentially achieve a higher level of trustworthiness. Today's global and integrated world faces several obstacles in managing complicated networks of suppliers and manufacturers. These complex ecosystems are straining companies' traditional approaches to supply chain management where a centralized actor controls and manage the data, or data is concentrated in separate silos and information is not shared between entities. The collaboration between BCG and MIT lead to the findings that blockchain could be a solution to these concerns. The technology offers a more decentralized approach to data sharing and management, and can improve the "transparency, speed, and responsiveness of these complex ecosystems" (Ganeriwalla et al., 2018). The importance of decentralization was confirmed by Graubins and Arandel. This decentralized trait of the blockchain enables an immutable trail of the data. Graubins calls it a trust-less system where the different actors actually do not need to trust each other. An analogy can be drawn to bitcoin, which the reader by now should know are built on blockchain technology. When transacting with bitcoins, the traditional intermediary is removed from the equation and two individuals can theoretically trade directly with each other. An illustration of the example is shown below (Figure 4):

Figure 4 - Validating Transactions



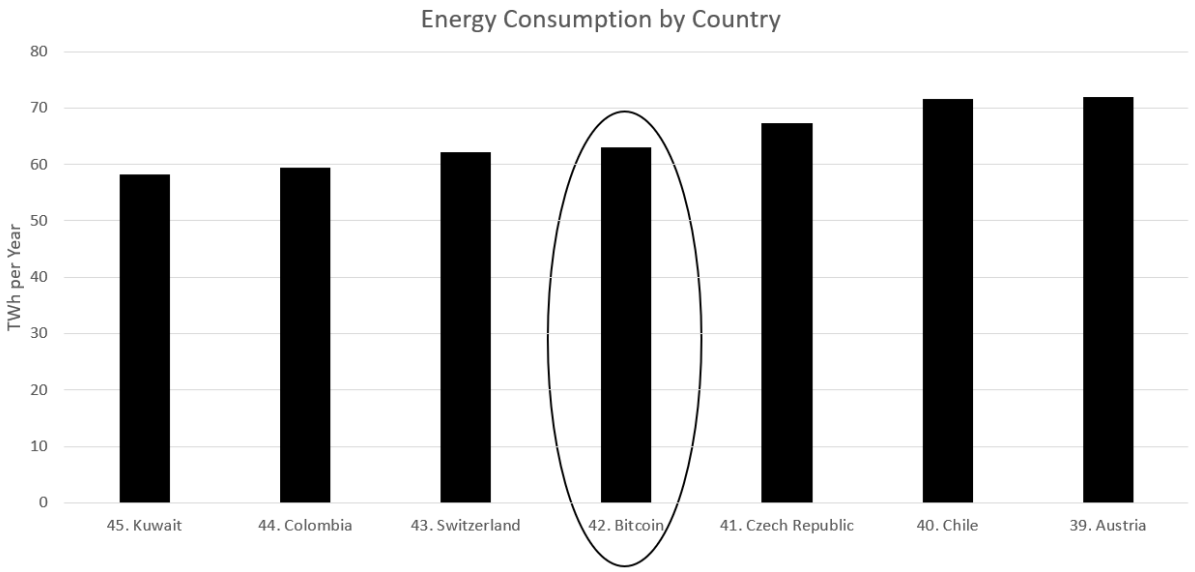
Source: own representation

Preethi Kasireddy, CEO of TruStory, affirms that when people say blockchains are trust-less, it implies that there are mechanisms in place in order to derive the canonical truth (Kasireddy, 2018). The power and trust are shared among the network's stakeholders and by using the blockchain system, the actors can reach a consensus. A blockchain's decentralized network of computers record each transaction made by any actor in the supply chain in a shared ledger that is constantly and collectively updated in real time (Ganeriwalla et al., 2018). The benefits of a decentralized supply chain are a recurrent topic by the interviewees. The concept of decentralization is about distributing the power (and data) among the supply chain actors and making decisions on a more localized level. Voje pointed out that they found blockchain interesting because no central authority controls the data and it facilitates information sharing. In order for a supply chain to be agile and continuously adapt to the supply and demand, a more decentralized approach is favourable. Some disagree that private blockchains are completely decentralized, but due to the consensus mechanism required to validate transactions, the self-regulated process does not rely on a central point of governance to approve transactions. Because of this, blockchain itself is capable of automating transactions within the supply chain (Schvartzman, 2018).

4.3 Blockchain

A growing concern regarding one of blockchain's consensus mechanism, Proof-of-Work, and especially Bitcoin, is its huge energy consumption. It is estimated that Bitcoin consumes an equivalent amount of energy as the whole country of Switzerland (Digiconomist, 2019). Below is a graph that shows the estimated energy consumption of Bitcoin as of 28-05-2019, compared to other countries (Figure 5).

Figure 5 - Bitcoin Energy Consumption



Source: own representation. Based on Digiconomist (2019).

Additionally, one bitcoin transaction consumes as much energy as 300 000 VISA transactions (Digiconomist, 2019)! The interviewed respondents highlight the importance of configuring the blockchain depending on the business issue you are trying to solve. Their view is confirmed by the World Economic Forum (2018), which also points out that the overwhelming hype surrounding blockchain is actually hindering its growth. This level of evangelism is not only misleading and untrue, but translates into a barrier for decision-makers in taking a balanced perspective (regarding the technology). It therefore becomes imperative for decision-makers to ignore the hype and truly examine what real business problems the technology aims to solve for the organization. A respondent from a supplier of food processing solutions told us:

> "*... from a business point of view, in the products that consider blockchain as part of the solution, more than 90% of it is business use case discussion, 10% is technique*."

While the application of technology to improve business processes is nothing new, the blockchain also implies dramatic redefinition of the processes associated within and between the companies in the value chain (World Economic Forum, 2018). Designing the blockchain

after the specific business case is thus important and there are a lot of choices to be made. One issue is the trade-off between *scalability*, *security*, and *decentralization*. Vitalik Buterin, co-founder of the cryptocurrency Ethereum, has coined this issue the "scalability trilemma" and points out the difficulty of achieving all these three properties simultaneously (Liu, 2019). *Decentralization* enables censorship-resistance and allows anyone to partake in the ecosystem. *Scalability* relates to the ability to process transactions on the network. Lastly, s*ecurity* is about the immutability of the ledger and its resistance to attacks. Currently, public blockchains such as Bitcoin and Ethereum, were designed to reach a high degree of decentralization and security but this comes with a cost of scalability (Asolo, 2018). Today, there is somewhat consensus regarding the co-existence of many blockchains in the future and this image is strengthened by the respondents, *"there will not be one blockchain to rule them all"* - Beck. Some blockchain developers are therefore focusing on specific problems across industry verticals instead of producing general blockchain applications. Businesses need platforms with customizable consensus parameters spurring blockchain providers to offer Blockchain-as-a-Service (Liu, 2019). The developers need to figure out what problem the blockchain should solve and why. Sirén explained that their ambition was to create the world's most transparent dairy value chain and they explored several solutions in order to achieve it, and in the end, they chose blockchain. The technology choice was based on its inherent features which enable transparency and traceability in the value chain. Jansson accentuated the fact that when the ambition entails illustrating the product's journey to the consumer, a completely private blockchain is often not the answer. The consumers need to be given at least reading rights of the blockchain and preferably also a way to convey feedback conveniently. Additionally, he states that the proof of work consensus mechanism is not optimal for the dairy industry, instead a set up with a fixed number of nodes is more suitable. In a supply chain anyone should not be allowed to be a node and add data (as in public blockchains) if the goal is a scalable solution, and minimizing the energy consumption.

4.4 Food Safety

One of the major issues that affect the food industry as well as dairy market regard the amount of waste that is generated along the entire supply chain. According to the FAO (2019), around

one third of the food that is produced globally is lost or thrown away, reaching 1.6 billion tonnes per year. To give the reader an image of the magnitude, this is equal to ten times the mass of Manhattan (Hegnsholt et al., 2018). And when it comes to dairy industry only, the figures remain critical. Researchers at Edinburgh University estimated that around 16% of total milk produced in the world is lost or wasted along the entire supply chain, amounting to 116 million tonnes per year (Gross, 2018). According to Professor Peter Alexander, almost 50% of the global milk is wasted before reaching the shelves (Gross, 2018). Broadly speaking, the challenges in food waste come from both upstream and downstream in the supply chain, with consumers playing a big part (The Economist Intelligence Unit, 2018). It's not only a matter of sustainability, there is also the financial side of the problem. To this extent, it is estimated that in a country such as UK, household food waste is worth around £15 billion, and consumers are not aware of how much income they are losing (WRAP, 2018). And although awareness among consumers is growing, the challenge of food waste remains dominant in developed regions such as Western Europe. Lack of awareness is also among the various reasons for the food waste issue that are identified by Hegnsholt et al. (2018) – the others being inadequate supply chain structure, ineffective supply chain efficiency efforts, poor collaboration across the value chain and insufficient regulations.

Another limitation to better food consumption comes from poor food labelling. A report from the European Commission published in February 2018 shows that up to 10% of food waste in Europe is attributed to date marking (European Commission, 2018). Consumers are often unaware of what is the actual expiring date and what "best before" or "use by" imply. This issue is probably easier to tackle, compared to consumer awareness, and relies on new digital technologies such as RFID. By installing RFID tags on fresh produce batches, retailers have the possibility to know that a certain temperature has been maintained throughout the transportation journey (Jedermann et al., 2014). Additionally, Beck mentioned that 15% of food and beverages sold worldwide are counterfeited and potentially dangerous. By pairing these new labels with a blockchain technology, consumers (and retailers) are able to see that the products they buy have passed the "quality" check and can be consumed without any risks for human health. As stated by The Grocer (2019), by enabling higher transparency over the entire supply chain, blockchain can improve the decision making and eventually reduce the waste. Blockchain is a secure digital ledger that enables sharing information in real time both upwards and downwards along the supply chain, from farm to shelf (The Grocer, 2019). This means that blockchain, paired with IoT devices, has the potential to drastically reduce the administrative

work and manual processes that have usually characterized the food industry, and dairy has not been exempted. This has also been highlighted by several of our respondents as one of the major benefits associated with adopting blockchain (Arandel; Jansson). But as pointed out by Borgelin, the dairy (and food) industry has not went through a full digital transformation phase yet. This, on one hand, offers almost endless opportunities for blockchain to disrupt the current markets, but on the other side has also proven to be an obstacle to its implementation. Borgelin:

"*I think the biggest obstacle we faced was the digital transformation that hasn't happened in the food industry*."

4.4.1 Food Recall

The old methods such as manual and paper-based processes affect the food and dairy industry also in terms of food recalls (Leong, Viskin & Stewart, 2018). According to Beck, food recalls have a strong impact for the food and beverage industry, causing *on average* around $10 million in the form of direct costs and up to $60 million as indirect costs – measured as impact on sales and reputation generated by each recall (Siemens, 2018). Blockchain technology has the ability to drastically reduce the data reconciliation, thus ensuring faster recalls and considerable cost savings. It can take up to several days and weeks to actually being able to identify the exact point of contamination, and this generates further illnesses, lost revenue and food waste. According to World Health Organization (2015), around 600 million people become diseased each year because of contaminated food, and more than 400 thousand actually die. To this extent, a clear example has been provided by IBM and Walmart, where they managed to significantly reduce the time and resources needed to track a product with the help of blockchain (Aitken, 2017). But why blockchain technology and not another traceability system? The answer came directly from F. Yiannias, VP of Food Safety at Walmart at the time of the project: "*I really had an 'aha' moment once I deeply understood the technology. I had been hesitant about creating another traceability system – the ones we had tried in the past never scaled. Now I understand that was because they were centralized databases. Blockchain, with its decentralized, shared ledger felt like it was made for the food system!"* (Hyperledger, 2019).

Golden State Foods (2018), mention that blockchain technology perfectly addresses the food safety challenges because it establishes a trusted ecosystem for all the transactions. Farmers, producers, retailers, regulators and consumers can be granted permissioned access to verified information about the origin and status of the food for their transactions. Additionally, Suzanne Livingston – IBM Food Trust Offering Director – explains in a podcast the major issues that hinder food safety and how blockchain can be the right solution (Engel, 2019). In short, many of the food product categories – including dairy – are fresh products, whose integrity relies on a safe and timely supply chain, from farm to fork. The data are still gathered and shared with old methods, sometimes just by pen and paper, thus considerably lengthening the time to tackle a recall (Engel, 2019). To this extent, one of the key problems that was highlighted in the literature – the so-called Bullwhip Effect – plays an important role also in the food industry. Borgelin highlights that this effect, although being established for more than 60 years, is still affecting today's supply chains, in the shipping and transportation industry as well as in the food chain. And returning to what Suzanne Livingston highlights, improving efficiency is fundamental in the food supply chain, where the freshness of the products could result in higher waste if the data are not shared in a real-time process (Engel, 2019). Lastly, Jansson highlights that there are other opportunities for companies involved in food safety ameliorations: beyond the fact that they can identify contamination sources more efficiently and reduce the cost of their recalls, at the same time corporations have the chance of improving their CSR policies and comply with standards and regulations.

4.5 Privacy and Regulations

Whereas compliance with regulations is an opportunity for many food companies in terms of improving food safety, lack of regulation regarding the blockchain technology is hindering its proliferation. A recent survey from PwC (2018) found that regulatory uncertainty was the greatest barrier inhibiting the adoption of blockchain. So far, regulations have mainly focused on the financial applications of blockchain, trying to establish a new set of policies for cryptocurrencies, and on fundraising in the form of *Initial Coin Offering*. To this extent, some countries (Singapore, Switzerland) and some single states in the US have already been trying to regulate tokens (PwC, 2018). This primary focus on the financial side has been confirmed

also by Graubins. When it comes to supply chain, Graubins and Arandel do not see any particular issue linked to the lack of regulations. Graubins affirms that the challenge for blockchain in supply chain does not come from regulations:

"*[…] the challenge is actually for all the parties to agree to use this technology, and then also implementing the technologies that would support these kinds of use cases".*

However, both Graubins and Arandel as well as other consultants highlight the fact that blockchain (in supply chain) could find some degree of resistance within the context of the current EU GDPR policy, which becomes a relevant concern given the geographical focus of this paper. To this extent, an interesting approach – although one of the few that looks at the issue in a rather optimistic way – comes from the research institute CGE that focuses on digital supply chains. According to CGE (2019), the major obstacles derive from the GDPR's "right to be forgotten" standard; this principle clearly clashes with the immutability nature of the blockchain technology – this concept is now well established and referred to as "Blockchains never forget" (Micron, 2019). Nonetheless, the study developed by CGE (2019) identifies four guidelines that should help blockchain companies to comply with GDPR standards. To be specific, the institute recommends: to use private, permissioned blockchain; to avoid storing personal data on the chain; to establish a detailed governance framework and to employ innovative solutions to data protection problems (CGE, 2019). But how is this possible in practice, especially when it comes to storing the data on the blockchain? This relies on two of the most complex but fascinating features of the blockchain – *hash function* and *zero-knowledge proof*. Without navigating in all the technicalities of these aspects, a brief explanation is beneficial to the reader. A hash function takes an input of any length and transforms it into an output of fixed length; importantly**,** the same input will always produce the same output (Jordan, 2018). But why is this relevant in terms of privacy and GDPR? Because the hash is a "codification", an algorithm that goes on the chain, while the personal data will remain off the chain (CGE, 2019). Another aspect that enhances the possible compliance with GDPR is given by the fact that hashing is defined as a one-way process, meaning that it is really easy to calculate the output (given the input) but it is nearly impossible to reverse the process (Mahler, 2018).

The other concept – *zero-knowledge proof* – can be defined as the ability to prove a secret without revealing it (Massessi, 2018). To give the reader an understandable example, imagine to be in a cave with a friend and a door obstructs the way to the exit; the friend knows the code (the secret) to open the door; what he then needs to do is just to open the door, thus proving he knows the code without revealing it (Massessi, 2018). And this is the same principle upon which many blockchains work. This important concept was also mentioned by Graubins as another potential source of compliance with GDPR:

"[with zero-knowledge proof] still you don't see the data. So, you would just trust the code, basically, [since] it gives you the correct answer."

Regulations play an important role in the field of food supply chain in Europe. Interestingly, in the end of May, the European Commission published a proposal about increased price transparency in the agricultural supply chain, which will be instated in the second half of 2019, after 4 weeks of consultations (European Commission, 2019). The Commission declares that the included measures have a broader scope than current data collection systems and procedures (Southey, 2019a). The commission further recommends that Member States "pursue a cost-effective approach for their reporting" European Commission, 2019). The proposal final aim is to improve fairness in selected supply chains, such as dairy, by enhancing price transparency (Southey, 2019a).

4.6 Transparency: Marketing or Supply Chain?

The provenance of products used to be pretty obscure and even today the information provided, and easily accessible, is often a simple "Made in China" stamp. However, as mentioned consumers are demanding a higher degree of details today and they care about issues regarding quality, ethics, and environmental footprint. Corporations are trying to make bold assertions ensuring their ethical supply chain management and transparency, at a granular level, embodies credibility to those claims (New, 2010). There are two sides of the coin and companies can

exploit the operational and/or marketing opportunities enabled by sophisticated tracking. The main driver for Arla, in the quest for a transparent supply chain, was the consumer need in terms of knowing more than just the provenance of the product. Sirén, explained that there was no ambition to tackle supply chain specific challenges at the nascent stage of the project. Blockchain can be used as a tool to boost traceability across the supply chain and leverage consumer trust in the brand (Southey, 2019b). The start-up SeeHow uses its blockchain-powered platform to offer a window into a global supply chain (Southey, 2019b). The solution instils trust into what is projected to the consumer and is used as a means of marketing and advertising campaigns. Borgelin brought up a recent example of an organic farm in Finland trying to visualize to the consumer how their animals were treated:

"*...the consumers were horrified and they thought "hey you are torturing the animals". The truth is that they [the farm] represent the top of the line in organic and animal wellbeing*."

Despite the fact that the farm was one of the best, the consumers were shocked by the reality and Borgelin highlights that communicating information to the consumer is a science of its own. Chain Business Insights (DeCovny, 2017) survey of supply chain professionals showed that sharing information with customers was the fourth most likely use-case for blockchain. Tracking products in the supply chain was the most likely activity for blockchain usage and the respondents pointed out improved supply chain visibility, reduction of transaction costs, and enhanced trust between supply chain partners as the most important advantages of blockchain. Beck:

"We think that many of the benefits to the organization and efficiencies cost gains are [going to happen] prior to sending data to the consumer. We think that there's logistical costs, information sharing costs, contractual obligations being approved more efficiently."

Basically, he believes there are efficiency aspects in the supply chain which can be utilized without connecting it to the consumer. However, the value creation enabled by the blockchain

is maximized when all the actors in the supply chain are connected to it. Incentivizing the actors is an obstacle and potential benefits differ depending on the specific supply chain. An example provided by Beck comes from the food and beverage industry where the products are perishables and Just-in-Time deliveries are of essence. By being connected to a blockchain ecosystem, the distributors of goods have the possibility of sending delivery notifications to the manufacturer. Beyond this, the use of GPS data in combination with the blockchain enables the distributor and manufacturer to create smart contracts to streamline the transaction. Sirén told us that smart contracts are an excellent feature of blockchain and something that could bring value to companies such as Arla. However, due to the willingness to deliver the project within a few months and the focus being on marketing, smart contracts were temporarily not considered.

Late deliveries are bound to happen, but by utilizing a blockchain the actors would be able to track products in real time and make adjustments in production in order to reduce the damage. Beck explains the possibility of a new arrangement between the manufacturer and distributor where the penalty of late deliveries will be less severe if the manufacturer is notified. Then the distributor has an incentive to share information. Reciprocal benefits between actors facilitates the implementation of a blockchain in the supply chain. Arandel highlights transparency as the biggest advantage of a blockchain and its positive affect on brand reputation. Additionally, the increased information sharing among actors and the immutability of the data prevents fraud and mitigates the operational risk. Arandel:

"For supply chain I think it [blockchain] reduces the cost in terms of administration especially, so that you have less people needed to reconcile information."

Graubins adds that blockchains can increase the transaction speed, and reduce settlement- and transaction costs in general. An important aspect brought up by the respondents is that transparency does not imply sharing all information. Arandel explains the possibility of configurating the blockchain so that only relevant data is shared.

4.7 Arla Milkchain

Arla Milkchain is a pilot project conducted by Arla, Empirica, and Truly Agency in order to create a transparent supply chain with one of the first blockchain applications in the dairy industry. Sirén:

"When we started working with the project, we set an ambition that we wanted to create the most transparent value chain in dairy."

Peltonen emphasized the relatively agile and lightweight process of developing and launching the pilot, which took months instead of years. The idea was to put a minimum viable product in the market quickly and utilize the market response to co-develop the system in symbiosis with a learning process. Arla is a challenger in the Finnish dairy market[4] and utilizing any tools necessary to gain a competitive advantage is of essence. And the blockchain was seen as a potential way for achieving differentiation. Peltonen mentioned Arla's ambition to meet consumer demand regarding sustainability and more transparent products. The size and complexity of Arla's supply chain complicates the ability to reap the potential benefits of supply chain efficiencies enabled by transparency at this stage. Therefore, focus was targeted toward the marketing approach rather than efficiencies in the supply chain. The choice of blockchain was based on its native features, enhanced reliability and shareability of data, and on the fact that the farm and the dairy are separate entities from Arla[5]. So, the technology was utilized to

[4] Valio is the leading brand.

[5] Hämeenlinna is the cooperative dairy and Tikka is the farm.

create trust between the supply chain actors and the end-consumer. Borgelin believes the added trust originates from the visibility granted by the producer, and publicly lying about this data would be devastating and deter future consumers. This volunteer exposure of data by the supply chain actors further reinforces the trust from consumers in the company's products. Another point touched upon was the digital transformation culture, which Sirén meant was easier to positively influence when introducing a relatively new and futuristic technology in order to fuel the excitement of the employees. Getting the different actors in the supply chain on board is fundamental, but was relatively easy due to their shared vision of providing a transparent supply chain to the end-consumer. According to Sirén, customer feedback has been positive, which is in line with previously mentioned surveys regarding how much customers value transparency. The project involved the launch of a new premium milk product[6] with the blockchain service supporting it. However, their vision extends the premium segment and the ambition is that this initiative will drive the market forward, making traceability and transparency an industry standard. Sirén believes the consumers deserve transparency end-to-end, knowing the true provenance and journey of the products. Borgelin emphasized the fact that there are many different actors involved and the aid of technological devices such as IoT sensors and milking robots which collect and transmit the data to the blockchain is imperative. This verification enabled by the technologies reduces the need for third-party validators. However, Sirén pointed out that because of the nascency of the technology some sort of third-party auditing is necessary in the beginning to ensure the consumers that everything is legitimate. Using the data obtained from the blockchain for improving efficiencies and streamlining the supply chain is something that is not fully utilized at this moment, but is under consideration. Sirén recognized that there are some general efficiency gains currently in the supply chain, but it is difficult to quantify them and is something that should be investigated further ahead. From a marketing approach, the project has generated return on investment and the buzz around Arla Milkchain has far

[6] The product is called Single Estate Organic Milk or Ydhen Tilan Luomumaito

exceeded the Finnish borders. The huge media penetration, composing of hundreds of articles, has enhanced Arla's brand equity and their vision has been projected to the consumers. Peltonen:

"...from a PR standpoint it [the Milkchain] has definitely been a big success. It's been covered globally and in Finland."

The investment required to generate and launch the project was fully financed by Arla. The dairy cooperative and the farm also put in effort however, due to the fact that the working process was altered and demanded the actors to comply. When asked about which type of blockchain is optimal for the supply chain, Borgelin explained that there is no straightforward answer but he believes that the consortium type makes more sense. Then the companies involved will fund the computer power required to run the network. Additionally, he stated that the consensus mechanism used in Milkchain is similar to the publicly described proof of authority. The biggest obstacle when implementing the solution was the fact that the digital transformation had not really occurred in the dairy industry and many steps still utilized paper and pen to track transactions. When talking about blockchain in general, Borgelin stated that increased transparency can lower the transaction costs by streamlining the transactions. Blockchain removes middlemen and can potentially create alternative sales channels. Borgelin:

"I am not saying it will be peer-to-peer in anytime soon, but there will be some disruption related to retailers and how food can be sourced."

What really unites the different actors are the shared vision of creating a transparent value chain to the consumer and this is also fuelling enhanced collaboration in the supply chain.

4.8 Additional Findings – Private Labelling

As mentioned, private label milks are dominating the European dairy market. An interesting remark by Baars and Graubins was that the private label milk offered by supermarkets are often the same product as established brands, such as FrieslandCampina. This means that the branded milk, which has a brand mark-up price, is the same as the cheaper private label alternatives. The supermarkets then have the power to reject brands or put pressure on the processors to reduce the milk price. Baars emphasizes that the retailers put low price on milk to attract customers and then they sell other products with a higher margin. Graubins believes that increased transparency could have an impact on the choice consumers make:

"...if you would be able to track that the products are actually the same, of course that would disrupt the market."

Even though the blockchain remarks were implicit, other respondents did not follow suit. Beck does not believe that products will be commoditized due to higher degree of transparency, at least not in the early phase. He thinks that the technology will be utilized for high quality products in the beginning, but in the long term it could cover more products. Thus, the technology will mainly be used to differentiate products. Sirén mentioned that products being the same under different brands is a characteristic applicable to every food category, and even beyond food. The level of transparency companies are willing to take affects the brand image and he believes this development is driven by marketing reasons. Additionally, there are opportunities and challenges connected to this depending on which perspective is taken.

5 Analytical Discussion

The following section aims at presenting the analysis of the patterns uncovered in the empirical findings. The purpose of this analysis is to understand how the empirical data suit the theoretical framework or whether they disagree upon the magnitude of the underlying factors. In order to facilitate the reader's understanding about the interrelations between the literature and the empirical data, this section will follow the structure of the theoretical framework (see Figure 3). The different paragraphs in this chapter will also incorporate a discussion, with the aim of going beyond the mere analysis of the interplays between theory and findings.

5.1 Traceability

Traceability can be as simple as knowing the provenance of the product, as difficult as a more complex representation with details regarding everything from time-stamping of the different steps to the energy consumed throughout the process. As argued by Wang et al. (2019), traceability is one of the four areas in which value can be enhanced in the supply chain. As Borgelin pointed out, today's regulations require a moderate level of traceability in most supply chains: that is, companies are only obliged to keep track of data one step back and one step forward. But what about the suppliers' suppliers and customers' customers? Consumers today demand more transparency, thus making end-to-end traceability a necessity in order to deliver a real transparent picture to the final consumers. In line with Golan et al. (2004), the empirical data show that improved traceability lowers distribution costs and reduces the inefficiencies along the supply chain. Efficiency is enabled by more accurate traceability with regard to food recalls, for instance. Being able to immediately track the source of contamination – as shown by Walmart – can considerably reduce the losses and ensure food safety. Efficiency plays an important role in the quest for reducing the so-called bullwhip effect, which has been hampering supply chains for ages. Blockchain is a potential solution for this problem, speeding the digital transformation of the dairy industry and ensuring real-time tracking of products and trusted,

distributed information. But why blockchain and not another traceability system? Frank Yiannias argued that this technology is superior and more suitable than other systems because of its decentralized nature, facilitating information sharing across the supply chain, making it visible to the end-consumers. Information sharing, information asymmetries and coordination are recurring themes in the empirical findings as well as in the literature. Many respondents highlight the value of information in the new ecosystem created with the blockchain. Every actor has the right to access the information, which is shared in a transparent way (Tian, 2018). Information asymmetries are therefore mitigated, reducing the transaction costs and potentially enabling a redistribution of the power along the supply chain.

Traceability systems are also a potential tool for enabling differentiation and brand image (Golan et al., 2004). This was the major driver that led Arla to the adoption of a blockchain solution. Providing the consumers with a new solution for traceability for one premium product would hopefully bring a competitive advantage in the hands of Arla; the high-end product shows additional details that are otherwise difficult to discern, thus aligning with Golan et al. (2004). When asked if blockchain would create more differentiated or commoditized products, most of the respondents agreed that in the short term blockchain will be a solution that increases differentiation, as shown by the Arla Milkchain. However**,** we believe that in the long-run private labels could increase and reach the same level of trust that is now associated with established brands. Making it visible to the consumers that branded- and private label milk are the exact same product could potentially disrupt the market, given that private labels have a significantly lower price.

Traceability is strictly connected to transparency, as emerged during the data collection. However, Skilton & Robinson (2009) argue that the relationship between traceability and transparency needs further clarification. They believe that more transparency leads to increased traceability, but the opposite is not true when the supply chain is characterized by a few actors with loose relationships. Revisiting them, we argue that traceability does not bring any value if companies are not transparent and do not share the data within and outside the network. Academia and practitioners affirm that blockchain can play an important role in this ecosystem by facilitating data sharing among the transacting parties as well as instilling trust in the network - given its immutable feature. Going beyond Skilton & Robinson, we argue that transparency does not necessarily lead to increased traceability. What is the value of being fully transparent if a company cannot provide correct data? This is particularly relevant in food supply chains,

where being able to quickly trace the source of the products can mean huge savings in terms of food recalls. But more importantly, if a consumer can visualize the true origin of a product, being transparent helps building consumer trust in the brand.

5.2 Transparency

According to Sahin & Robinson (2002), a supply chain is entirely coordinated only when all the actors share the same interests and want to pursue mutual objectives. This was arguably one of the most relevant conditions that fostered the Arla Milkchain project. Sirén highlighted that having all the different actors on board is one of the toughest challenges when dealing with new projects. Nonetheless, this was relatively easy because all the parties shared the same vision – to create the most transparent dairy value chain. All the industry and consumer reports mentioned in the findings state it clearly: if the products are not transparent, customers will likely turn around and switch brand. To this extent, a stand-alone opinion came from Baars, who was quite sceptical about the magnitude of this trend. We agree with him on the difference between answering surveys and actually being in the supermarket making the final purchase choice. However, paraphrasing Prahalad & Ramaswamy (2004), it is undisputable that consumers are driving the demand for more transparency and companies should surf this wave in order to capture a greater share of the value.

Blockchain seems to be the perfect companion in the journey for a more transparent value chain. Blockchain offers a more decentralized approach to information sharing and can enhance transparency, speed and responsiveness of complex ecosystems (Ganeriwalla et al., 2018). Since no central authority controls the data, information can be accessed without barriers, allowing decentralized decision-making. But increased transparency and easier information sharing raise concerns from corporations. Today, data is the "new oil" and companies such as Facebook and Google have built their fortune on data and might have reasonable arguments not to share information. In the beginning of this research we shared a similar concern, but conducting the interviews, gathering secondary data and reaching a deeper knowledge about the technology made us less sceptical. In particular, Arandel clarified that more transparency does not necessarily imply sharing all the data. There are also techniques and inherent features in the blockchain such as zero-knowledge proof that allow for validating transactions without

revealing the information. Product data are kept on the blockchain, while proprietary information can remain off-chain.

Although the secondary data show that an increasing number of consumers demand greater transparency and that this should positively influence consumers' level of trust, excessive transparency can have negative consequences. This is highlighted by Borgelin, who mentioned that consumers were horrified when an organic farm in Finland showed how they treat their animals. Of course, this is not just a matter of transparency, but how this transparency is communicated to the end-consumer. This is an area where companies should dedicate resources, if they want to capture value from a more transparent value chain. It is not only about doing the right things, but doing them right.

Additionally, the empirical findings have strengthened a concept emerged during the literature review: transparency builds trust. However, Buell (2019) affirms that when transparency is enforced by investors or regulators, instead of being voluntarily provided, its value decreases steadily because it does not instil trust. Nonetheless, we argue that some degree of regulations towards more transparency might be beneficial in the short term, without necessarily depreciating trust. The proposal made by the European Commission about increasing the level of transparency is one step closer in this direction. We believe that companies embracing higher transparency can potentially gain a competitive advantage. Regulators can force corporations to show a more transparent supply chain, but we argue that this movement has already been initiated by companies – in order to respond to consumer demand. Blockchain is, to our knowledge, the best technology to ensure and communicate this greater level of transparency, and in the future organizations might be forced by institutions to join a blockchain platform in order to build a trusted ecosystem. Therefore, transparency reinforces trust regardless of who drives this shift. Blockchain seems to be the perfect ally in this ecosystem and we believe it should be considered by corporations involved in supply chain. Because of its immutability nature, trust is embedded in the network and the quest for a more transparent supply chain is a perfect business case for blockchain. By connecting data along the supply chain, blockchain can enable transparency and real-time sharing. We argue that increased transparency makes opportunistic behaviour easily detectable, thus minimizing the level of uncertainty in the network. This entails that trust is then enhanced, reducing transaction costs.

5.3 Trust

Overall, the empirical findings indicate that trust among actors is essential in supply chains, and is a recurring feature of blockchain. In line with Zand's (1972) definition of trust, it seems that when individuals expose themselves and become more vulnerable, the trust towards that individual increases. Being transparent and explicitly stating what is happening within companies' supply chains implies becoming more susceptible to scrutiny. If a company publish misinformation, their reputation would be tainted, therefore this risk is minimized. Transparency instils trust in the organization, from both the counterparties in the supply chain and from the end-consumer. It is easier to trust an organization that actively convey the reality compared to one staying silent.

Investing in relation-specific investments implies a higher degree of uncertainty and opportunism by the counterparty. As argued by Williamson (1985), complex contracts can act as a safeguard to this risk, but Telser (1980) and Sako (1991) offer other perspectives. They highlight trust and self-enforcing agreements as means to protect against the hazards of opportunism. Both these aspects are highlighted by the respondents in the form of smart contracts and automated trust enabled by the blockchain. However, it was difficult to pinpoint the type of trust enabled by the blockchain since the respondents' view differed. The opinions varied from "trust-less", "trust-more", automating trust and removing trust from the equation. What was coherent among the respondents, was that blockchain does impact trust. Historically, third-party organizations, such as governmental bodies or NGO's, basically had a monopoly on trust, leaving companies no other choice than to rely on them. The blockchain enables companies and individuals to transact peer-to-peer without the need of a central coordinator. This shift has several implications; reinforcing trust, streamlining transactions, and reducing contractual- and other transaction costs. For this to happen, the trust towards blockchain needs to be entrenched. In order to understand this, it is necessary to revisit Lippert's (2007) paper about implementing new technologies in supply chains. He argues implementation is hindered by two types of trust; interorganizational trust and trust towards the technology. Our empirical findings indicate that interorganizational trust seemed to be the most pressing obstacle when implementing the technology. Interestingly, the blockchain was never mentioned as an end-goal in itself. Several solutions were considered before deciding that the blockchain was the most suitable technology for achieving the goal of a more traceable and transparent supply chain. A coherent thread among the respondents appeared to be that they were humble regarding

the technology, reducing the risk of getting caught in the hype around it. The trust towards the technology has steadily increased during the past years, and an increasing number of organizations are using it. However, even among the organizations utilizing blockchain, it became evident that the technology was still in its infancy since pilot projects were conducted. This is a logical and natural development of a new technology though, and the trust towards it will augment after successful use cases.

Gouldner's (1960) argumentation of real trust stemming from reciprocal relationships and Zajac & Olsen's (1993) statement that shared purposes among actors enable beneficial outcomes, seemed to characterise the Arla case. A facilitating factor orbiting around the interorganizational trust issue was the shared vision of the involved actors. The common mission of creating a transparent supply chain instilled the actors with a feeling of reciprocity and trust towards the other participants. Powell (1990) emphasized the importance of reciprocity and collaboration between actors, and introduced the network as a distinctive form of coordinating economic activities. Similarly, an integrated blockchain network in the supply chain results in deeper collaboration, implicitly and explicitly. Firstly, the actors must decide on rules in the ecosystem. Secondly, the information sharing is expanded and a more comprehensive picture of the operations is formed. Lastly, the enhanced transparency and trust reduce the propensity of opportunistic behaviour. Building on Hill's (1990) reasoning regarding the invisible hand mitigating the risk of opportunistic behaviour, the findings indicate that the blockchain further mitigates this risk. There are two reasons for this: the presence of mutual benefits, as well as joint efforts of the actors in order to set up the ecosystem. This is also influencing the trustworthiness of the actors involved, since they collectively have something to lose from abusing the relationship. Trust in supply chains is highlighted as a source of efficiency by Francisco and Swanson (2018) and although their claim is not sensational, our findings correlate with this phenomenon. It became evident that trust, whether it is towards the technology or towards the counterparty, streamlines the supply chain.

We agree with Williamson (1975; 1985) that trust is difficult to operationalize, nevertheless its significance is too critical to ignore. But what is trust in business and how is it affected by the blockchain? According to us, it is not only about trust, it is also about accountability. It is about a technology which facilitates conveying the truth by using complex verification algorithms. Without becoming too philosophical, a connection can instead be drawn to Airbnb. Ante-Airbnb, people were reluctant to rent out their accommodations to strangers, mainly due to trust

issues. Post-Airbnb, the proclivity increased, but did the trust toward strangers increase? Human behaviour does not change overnight, but what Airbnb and other sharing economy platforms do is relying on a systematic review and safeguards to protect the users. This is the magic of peer-to-peer networks, in which the community reach consensus regarding the "truth"[7]. We arrived to a similar conclusion as Werbach (2018) regarding trust in the blockchain environment. The blockchain enables companies to transact in a more frictionless environment by trusting the system and information in it, rather than trust towards the counterparties. This lowers the uncertainty between the parties, thus mitigating one of the most influential determinants in transaction cost economics (Williamson, 1979).

5.4 Transaction Costs

In the genesis of this research, we assigned a lot of weight to the transaction cost side and how blockchain would affect it. During the literature review and secondary data collection this view was reinforced (Nakasumi, 2017; Korpela et al., 2017; Wang et al., 2019). However, when

[7] Just because there is consensus about something, does not mean it is true. Two millennia ago, when the majority of people reached a consensus regarding earth's geometrical form being flat, this was far from the truth.

interviewing the respondents involved in the Arla Milkchain, it became evident that this was secondary to the marketing side. Nevertheless, there was still a coherent image of blockchain being a facilitator of transaction costs in supply chains.

Transactions require companies to stipulate contracts, but due to bounded rationality it is basically impossible and also expensive to create contracts which cover all contingencies (Williamson, 1985; Powell, 1990). When the outcome of the transaction is uncertain, the cost is expected to surge. The findings indicate that this uncertainty can be mitigated thanks to automated trust and smart contracts enabled by the blockchain. Smart contracts are interestingly something that the respondents have not utilized in a great extent even if they see it as a possibility when transacting. By enabling self-executing contracts, the administrative costs would be reduced significantly. Companies would be able to make transactions in a timely manner, whereas, when specified criteria are met, the contract self-execute and the payment is done automatically. What we believe is that ultimately, the smart contracts could be utilized to connect end-consumers with companies, in a similar vein as TaskRabbit[8]. End-consumers could transmit to the blockchain that they want milk delivered and any company or individual willing to do this would finalise the delivery and get paid instantly. Although this is probably unlikely to happen in the near future, innovative and more convenient sales channels are always pursued.

Returning to North (1990) and Fiala (2004), and their view on information asymmetry being a source of inefficiency and higher transaction costs in the supply chain, it became evident that blockchain can mitigate information asymmetry. The respondents confirmed that blockchain is an excellent tool facilitating information sharing and enabling a more agile supply chain. Due to a peer-to-peer consensus mechanism and information being easily shared in real-time, the supply chain actors' possibility of adapting to changing events increases. Kwon and Suh's (2004) concern regarding the risk of information sharing among supply chain actors is not

[8] An online platform which matches freelance labour with local demand (TaskRabbit, 2019).

reflected in the respondents' answers. The uncertainty and risk of abusive behaviour seemed to be negligent. This was in part explained by the possibility of only sharing relevant and selected information, and how the blockchain could be configured so the data was encrypted or only certain entities were given reading rights. The other part was once again due to the fact that the involved organizations shared a vision and expected mutual benefits. It was emphasized that the information sharing was a step-wise process starting with sharing a few data points. The trust and transparency translate into increased information sharing, enabling the companies to streamline transactions and processes. Additionally, Just-In-Time production is facilitated due to the real-time tracking, which entails lower uncertainty.

Transaction cost economics focuses on how transaction costs occur and how companies should organize their economic activities (e.g. market or hierarchy) (Williamson, 1975; 1985). Zajac & Olsen (1993) argue that this narrow attention on costs is inadequate and the pursuit of joint value needs to be incorporated. Their view corresponds with our findings, where the respondents accentuated that the pursuit of joint value should be the driving force when developing supply chains. The blockchain enables this by creating mutual benefits and reinforcing the cooperation between the actors. A common thread was ensuring that the new technological solution delivered value to every actor. This, in turn, facilitates the implementation of blockchain since actors not gaining any value would be reluctant to connect to the ecosystem. Powerful companies, such as Walmart, took another approach and used their bargaining power and forced the suppliers to join the blockchain. Although this is one way to proceed, we believe every actor in the supply chain must acknowledge that the technology is bringing value to them. This will maximize its utility and ensure long-term value.

5.5 Customer Benefits

Beyond lowering costs, companies have a mission to create products or services which consumers value. Consumers' willingness-to-pay is therefore a central aspect in companies' quest for profit (Peteraf & Barney, 2003). Our hypothesis that customer benefit was secondary to the cost side was shattered. Enabling consumers to get a glimpse of how the company operates, appeared to be the primary use case for blockchain. Figuring out consumers' preferences becomes imperative. 15 years ago, Beulens et al. (2004) concluded that consumers

want detailed information about the food they consume. The empirical findings indicate that some companies also managed to solve this riddle, in the form of increased transparency.

As emphasized throughout this paper, consumers are demanding more transparency and yearn for sustainable and ethical products. Arla Milkchain is certainly in line with this trend. With the help of blockchain, their goal is to create the most transparent supply chain in dairy. Although we were not provided with any numbers regarding margin and sales of their new product, it became evident that the project succeeded. The mere media coverage of it was enormous, enhancing their brand value. Additionally, one can assume that the product has thrived due to the increased share of consumers demanding transparent products. The perceived benefit by consumers is the guiding force of their buying pattern and determines what price companies can charge for their products. The marketing aspect is therefore imperative in order to convince consumers where to spend their money. Kshetri (2017) argues that blockchain is a tool to gain trust and convey to the consumer that the food is trustworthy and safe. Deriving from our data collection, it became evident that the interviewed believed the same. Our initial concern was whether consumers should fully trust the blockchain. After researching about the technology and conducting the interviews, it became evident that the information coming from a blockchain are more reliable and trustworthy compared to other centralized systems. Thus, consumers should not have any particular refrain. Consumers do not need to understand the details of the technology; however, companies and institutions can provide some degree of public education towards the technology. This would certainly be beneficial in spreading the adoption of the technology, thus building on the consumer benefits.

Expanding on Golan et al. (2004) argumentation about traceability systems enabling better supply management, differentiation, and easier traceback for food safety and quality, it is evident that the blockchain enables differentiation as argue above. Additionally, as conveyed in the findings, the time for tracking a product's provenance could be reduced drastically. The three aspects highlighted by Golan et al. (2004) are thus confirmed in our research. Another emphasis should be given to the risk of counterfeit products. Although milk cartons costing 1€ do not bear the same risk of being counterfeit as cheese and wine, the consumer wants to know that the product is safe and trustworthy. Here the benefit of traceability and transparency is twofold, in terms of assurance to the consumer that the product is authentic, and in terms of trust toward the company's brand, potentially resulting in higher sales. Trust in brands is essentially what endows companies to charge a premium price. Brands enable consumers to

express themselves and making a statement of what they stand for. A company which is transparent and clearly conveys its values, brings a positive perception to the consumer.

Prahalad & Ramaswamy (2004) highlight the importance of interacting with the consumers for companies striving for value creation. They argue that consumers demanded a higher degree of transparency and this aspect has been augmented in recent years. Some degree of transparency has been conveyed with the use of food certificates, which have also provided companies with an opportunity to differentiate. By using a trusted third party such as Fairtrade to examine and evaluate the provenance of the products and work conditions of the farmers, the consumer has been ensured that it was ethically produced. However, as highlighted by the respondents, there are shortcomings with certifications. Products need to meet minimum requirements in order for them to get the certification. As a result, many different products obtain the same certification even though there could be differences between the products. This entails misappropriate advantages for some products and a disadvantage for companies going beyond the minimum requirements. Additionally, it's difficult to provide all the details about products' provenance and transportation conditions to the consumers. Arla managed this issue by using a blockchain solution to track the product. Detailed information regarding the specific carton is then accessible to the consumer online. This comprehensive understanding conveyed to the consumer, concerning how the product is made, is a true source of differentiation for the company.

5.6 Value

Creating value is arguably the most imperative goal for companies. As argued by Peteraf and Barney (2003), value is the difference between what consumers are willing to pay and the cost induced by producing the product. Thus, companies have the possibility to create value by reducing costs or increasing the perceived customer value of the product offered. Throughout this research process, we have always kept a close eye on both determinants of value creation and the underlying factors presented in the framework have a *raison d'être*. Moreover, as argued in detail in this chapter, linear but also bidirectional connections can be drawn between them in the quest for reducing transaction costs and enhancing consumer benefits. In this ecosystem, blockchain enables better traceability, transparency and trust in the value chain.

Shank and Govindarajan (2008) assign great importance to exploiting the linkages between actors in the value chain. They assert that the entire value chain, from raw material to end-consumer, must be considered in order for companies to enhance their competitive advantage. The respondents manifested that for a blockchain to reach its full utility, every actor in the value chain needs to be connected. If the farmer or the distributors are excluded or are not willing to participate in the network, the value of the blockchain decreases. Imagine having a traceability system disconnected from these actors, how can food safety be ensured? As argued before, certifications are inadequate since they fail to incorporate all aspects of a product and instead only include the upstream step of the value chain. The end-consumer is requesting a complete image of the value chain and only obtaining fragments of it is insufficient. Therefore, an incomplete traceability system cannot provide the same value as an exhaustive blockchain incorporating the entire value chain. A blockchain facilitates exploiting the linkages between the actors since it integrates the value chain and enhances information sharing. The increased traceability and transparency translate into opportunities for the companies in the ecosystem. By having a more comprehensive understanding regarding the value chain, it becomes easier to discover potential initiatives which could create mutual value.

Parkhe (1993) and Dyer (1996) found that mutual value can be enabled by relation-specific investments. These investments have the characteristic of being constrained to a certain transaction or company. The Arla Milkchain project was completely financed by Arla even though the other actors had to partially contribute. The respondents asserted that the project had mutual benefits for the actors involved and that this is a requirement for the project to be further developed. We believe the benefit side of the value will mainly be captured by the companies that have their brand on the end-product, since traceability and transparency will enhance differentiation. On the cost side, arguing which specific actor captures the biggest share of value is more difficult. It can be inferred that the value will be equally distributed among the participants. The reduction of information asymmetry will enable the participants to find common or individual solutions to tackle inefficiencies in the supply chain. Anand & Mendelson (1997) highlight four alternatives for sharing information and state that fully distributed systems are the superior choice. Although blockchain was far from its first use case when they concluded their research, Anand & Mendelson (1997) already acknowledged one of the most promising directions for modern supply chain ecosystems. A distributed and decentralized system enhances the integrity of the data and enables decision-makers to utilize the data. Accordingly, the decisions can bring additional value. However, if the data is incorrect,

its value decreases substantially. A blockchain can ensure the trustworthiness of the data, but when the primordial data input is incorrect, the entire chain becomes inaccurate. Human error, intentionally or unintentionally, is therefore a critical aspect to take into consideration. Nevertheless, due to the blockchain's technical features, we believe actors who intentionally want to falsify data would stay away from this particular ecosystem.

The implications of the blockchain should be further considered in regard to value capture, as Bowman & Ambrosini (2000) conceptualized. In similar vein as Porter (2008), they argue that the power relationship between actors has an impact on the distribution of value. As argued above, the value of the marketing effect will most likely be captured by the company which has their brand name on the product. After the dot-com bubble, companies operating online and engaging in data gathering have been experiencing a surge in their influential power. In the future, blockchain providers could obtain similar power. Conversely, the data and information are distributed in a more decentralized way within a blockchain ecosystem. Thus, one could argue that the power will be more distributed. Furthermore, being an early adopter and commercializing the technology is not necessarily synonymous with success. Every new technology that hits the market shows its full potential only when consumers adopt it or assign value to it. As emerged during the interviews, the end-consumers should be part of the blockchain, being the end-node of the network. This can give companies the opportunity to receive instant feedback about their product and be able to respond quickly to changing consumer demand. They make the final purchases, by assigning value to certain elements, and they have the power to influence the direction of companies' strategic investments.

6 Conclusion

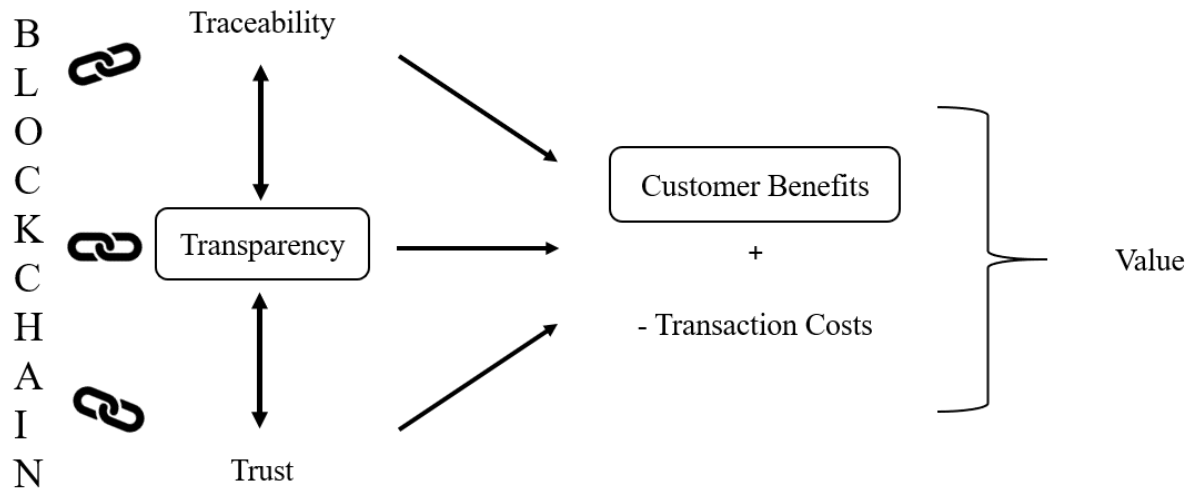
The purpose of this paper has been to analyse blockchain's role in the food supply chain and investigate some of the possible determinants and their interplay in creating value. Through the empirical data gathered in combination with past academic literature we have examined how blockchain could affect this ecosystem. Guided by the theoretical framework, the data has been analyzed deriving the following conclusions:

- *Traceability* affects the value of transparency, but better traceability does not directly imply higher transparency. Traceability directly influences customer benefits in strict combination with transparency. The blockchain is, as hypothesized, an excellent solution for traceability. Additionally, it can lower costs in the form of accurate and swift food recalls.
- *Transparency* is highly valued by consumers and is a way for companies to differentiate, in combination with traceability, and to increase customer benefits. Transparency has a bidirectional correlation with trust. Being transparent in a relationship increases trust among the actors. Transparency decreases the uncertainty, reducing transaction costs.
- *Trust* is a versatile vehicle in business. Trusting someone augments the proclivity of being transparent toward them. Consumers' trust in a brand increases their perceived value. Trust act as a mitigator for transaction costs and as a safeguard against opportunism.
- *Blockchain's* features positively affect traceability, transparency and trust. Moreover, blockchain can be used to directly lower transaction costs with the use of smart contracts. It can also help consumers visualize the product's entire journey through the supply chain. In a blockchain ecosystem the trust is automated, the actors trust but verify the information.

To conclude, the analytical discussion summarized above has led us to revise the initial framework. After empirically testing it, it became evident that all the determinants have a direct influence on both the benefit and cost side of value. Although trust can act as a safeguard against uncertainty and opportunism, transparency emerged as the most relevant factor in the new framework, with customer benefits having a greater impact than transaction costs in the creation of value.

The revised framework (Figure 6) has guided us through the fulfilment of the research purpose, as summarized by the research question: *How can blockchain enable value creation in the supply chain?*

Figure 6 - Revised Framework



Source: own representation

6.1 Theoretical and Practical Implications

The primary contributions of this research are twofold: theoretical development of a framework depicting the blockchain's impact in value creation, and derivation of empirical findings to obtain an illustration of how it is utilized in practice. The blockchain's impact in marketing appeared to be marginalized in the academic sphere compared to its utility in the business landscape.

The findings of this paper can be beneficial to both academics and practitioners. Our theoretical model combined academic literature from the fields of TCE, value creation, and supply chain. Our aim was to uncover the interrelations between these different theories integrating blockchain, and to our knowledge no previous work has been done in a similar way. Nonetheless, it was important to test our framework in practice, in order to show that these concepts can be consistent with business practices. In doing so, the abductive approach was critical. Going back and forth between literature and empirical findings, as well as conducting semi-structured interviews enabled the conceptualization and constant revisitation of some theoretical concepts. Namely, the fact that traceability, transparency and trust build on each other and ensure consumer benefits while lowering the transaction costs. Whereas the theoretical review led to concluding that trust was the bigger issue in the supply chain, influencing transaction costs, the findings highlight that the consumer benefits side is actually greater influenced than the cost side. This is a theoretical implication that could be further tested from academia, considering that blockchain is likely to be widely adopted in future supply chains.

Our study also provides practical implications for companies actively involved in the dairy industry in contexts similar to Western Europe. Additionally, we believe that our findings can be partially relevant to other food companies that deal with perishable products within and outside Western Europe. A practical contribution that emerged during the findings is that blockchain is a technology that shows its greatest value if there is a specific business problem to be solved. When this business problem involves traceability, transparency or trust issues in the supply chain, the blockchain should be part of the equation in order to enhance greater collaboration in the network, ensuring that every actor gain something. A recurring concern about blockchain regards sharing data and critical information, potentially lowering companies' competitive advantage derived from "secret" information. Our findings have demonstrated that

this is only partially true. Blockchain's features allow for validating data without sharing personal information or secret recipes. We believe that more education for consumers as well as companies would be beneficial in enhancing the benefits of blockchain and our paper humbly aims at fostering this education.

6.2 Limitations and Further Research

The theoretical and practical contributions of our paper should be evaluated in light of their main limitations. These limitations should enhance opportunities for future research. First, some methodological limitations need to be clarified. Although the discussion was kept on a broader level, the choice of one particular industry (dairy) in a specific context (Western Europe) could limit the generalizability of our study. Thus, further research could attempt to analyse the value creating role of blockchain in other related contexts. Furthermore, time constraints restricted our ability to investigate the entire supply chain on a direct level. To this extent, actors such as farmers and consumers were analyzed through secondary data; future research could then attempt to directly observe these important players.

Moreover, our framework has been empirically tested through a single case study due to the limited availability of similar examples in the dairy industry. Thus, although we tried to provide a holistic view in our process by gathering insights from other primary sources, we argue that future studies should consider the opportunity of analysing multiple cases in dairy or related industries. Once the blockchain is adopted on a bigger scale by different companies, quantitative studies could ensure greater reliability compared to our research. Future research could also extend on the trust aspect in the blockchain ecosystem analysing the type of trust enabled by the technology. Our proposed framework could function as a guide for future research and deep-diving into one of the factors could provide additional theoretical utility.

Additionally, even though the majority of the findings correspond with previous research regarding blockchain and supply chain, an interesting topic that could be worth investigating by academia relates to smart contracting and TCE. To this extent, food industry seems to offer promising use cases, dealing with several transaction costs across the entire supply chain. Thus,

our work could be of guidance to academics that aim at analysing blockchain and smart contracts from a TCE perspective.

Lastly, we think that future researchers could analyse the decentralized nature of blockchain compared to the centralized nature of an ERP system through a longitudinal case study, in order to find which additional factors are desirable in the blockchain. For this purpose, supply chains offer interesting use cases in different industries and our research could provide valuable insights and a good starting point for future researchers.

7 Appendix A

7.1 Interview Guide

Blockchain

- What are the biggest advantages with implementing a blockchain in the supply chain?
    i. How is traceability affected by blockchain?
- What are the biggest challenges when implementing a blockchain in a supply chain?
- How much trust is needed along the supply chain?
- How much the delaying adoption of the technology can be related to "trust" concerns among the actors involved?
- Which are the actors that can drive the adoption of blockchain in the supply chain?
- What are the differences between the types of blockchain? Which one is the most suitable for food supply chain and what are the reasons for this?

Transaction cost economics

- What are the effects of the blockchain on transaction costs when it comes to trust among the actors in the supply chain?
- Is there a higher risk/opportunity for companies to forward or backward integrate when they obtain all this information enabled by the blockchain?
- How do you manage opportunism and uncertainty in the supply chain?
    i. Do you think the blockchain is mitigating these risks or enhances collaboration between the supply chain actors?

Value

- Is it possible that blockchain will enable additional revenue streams for the actors?

- How do you incentivize the different actors in the supply chain to use the technology?

Risks/opportunities with blockchain

- What are the risks involved when opening the supply chain and sharing information with more actors?
    i. How do you draw the line on what information should be shared?
- What outcomes will be determined by blockchain when it comes to food products?
    i. Is standardization or differentiation the most probable outcome and why?
- How should companies in a cost-efficient way ensure that the information actors put in the blockchain is reflected by reality?
- What are the implications for all the various supply chain actors when having a more transparent supply chain?
- Do you use any third parties to validate the information inserted to the blockchain?

Dairy Supply Chain

- What are the biggest issues today?
- Who would you say is the strongest actor in the supply chain and how the blockchain could alter this?

Regulatory landscape

- Are there any regulations or policies regarding blockchain today?
- What regulations are needed to increase the trust in the blockchain system?

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