Blockchain technology in food supply chains

A case study of the possibilities and challenges with an implementation of a blockchain technology supported framework for traceability

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Blockkedjeteknik i livsmedelskedjor
En fallstudie över möjligheterna och utmaningarna med en implementering av ett blockkedjeteknikbaserat ramverk för spårbarhet

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Abstract

Throughout history, the food sector has been accountable for several crises, and as the market gets more global it is difficult to keep control of and trust the information. As a consequence to the food scandals, due to the information asymmetry, the customer awareness is increasing as well as initiatives such as certificates to address the problems. To be able to increase the transparency, the information infrastructure is constantly developing and most recently the technology of blockchain has gathered a lot of attention as a possible solution to the problems. A blockchain is an open, distributed and decentralized verification system for digital transactions where data about the transaction is stored safely in so called blocks which forms a chain in a network. In order to obtain food safety, it is necessary to have traceability systems that records and can provide product specific information.

This study investigates the challenges and possibilities of a possible implementation of a traceability system supported by blockchain technology. This research is made by a case study, looking into a food supply chain for a package of milk, starting at the dairy manufacturer and ending at the retailer. By doing interviews and observations, a mapping of the case specific supply chain was made and a blockchain technology supported framework for traceability was suggested. From analyzing theoretical data and empirical findings the possibilities and challenges of a blockchain supported framework for traceability was discussed.

The conclusion of the study is that the blockchain technology still is immature in the context of food supply chains and some of the biggest challenges are to develop a culture that promotes collaborations, information sharing and standardizations which are easy to adopt. However, blockchain technology has the possibility to offer secure and transparent traceability characteristics to a traceability system and a framework can lead to both cost and environmental savings in case of a product recall. Furthermore, to be willing to collaborate and to put time and effort into new implementations it is important to find the actual value of implementation for all stakeholders.

Keywords: *Food supply chain (FSC), Food safety, Blockchain technology, Traceability*

Sammanfattning

Livsmedelssektorn står ansvariga för flertalet skandaler, med en allt mer globaliserad marknad blir det än mer svårt att behålla kontrollen över information och lita på den. Som en konsekvens av skandalerna, till följd av informations-asymmetrin, har konsumenternas medvetenhet ökat såväl som initiativ så som certifieringar för att bemöta problemen. Informationsinfrastrukturer utvecklas ständigt för att kunna öka transparensen och blockkedjetekniken har den senaste tiden fått mycket uppmärksamhet för att kunna vara en möjlig lösning till problemen. En blockkedja är ett öppet, distribuerat och decentraliserat verifikationssystem för digitala transaktioner där data om transaktionen är säkert sparad i så kallade block som tillsammans bildar en kedja i ett nätverk. För att uppehålla livsmedelssäkerhet är det nödvändigt med spårbarhetssystem som registrerar och kan tillhandahålla produktspecifik information.

Studien undersöker utmaningar och möjligheter för en möjlig implementering av ett blockkedjetekniksbaserat ramverk för spårbarhet. Studien är genomförd som en fallstudie genom att undersöka en livsmedelskedja för ett paket mjölk som avgränsats till att börja vid mejeriet och sluta i matbutiken. Genom att göra intervjuer och observationer gjordes en kartläggning av livsmedelskedjan och ett förslag på ett ramverk för spårbarhet supportat av blockkedjeteknik togs fram. Från analys av teoretiska data och empiriska upptäckter diskuterades möjligheterna och utmaningarna med ett blockkedjetekniksbaserat ramverk för spårbarhet.

Slutsatsen av studien är att blockkedjetekniken fortfarande är en omogen teknik i kontexten av en livsmedelskedja och att några av de största utmaningarna ligger i att utveckla en kultur som uppmanar till samarbete, informationsdelning och standardiseringar som är enkla att implementera. Tekniken erbjuder däremot säkerhets- och transperensegenskaper till ett spårbarhetssystem och ett ramverk kan medföra både kostnads- och miljöbesparingar vid en produktåterkallelse. För att samarbeta och investera i tid och pengar för en implementation är det dessutom viktigt att hitta de faktiska värdena i implementeringen för alla intressenter.

Nyckelord: *Livsmedelskedja, Livsmedelssäkerhet, Blockkedjeteknik, Spårbarhet*

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Abbreviations

FSC – Food supply chain

DSC – Dairy supply chain

IoT – Internet of Things

RFID – Radio-Frequency Identification

ISO – International Standardisation Organisation

HACCP – Hazard Analysis and Critical Control Points

BRC – British Retail Consortium

PoW – Proof of Work

PoS – Proof of stake

PBFT – Practical Byzantine Fault Tolerance

Visma: Business administration software.

Movex/M3: Enterprise Resource Planning tool.

Relex: Automatic order triggering system.

OEBAS: Self-monitoring software.

WebMethods: Supportive order administration software.

Block: A group of transactions in chronological order. Contains of a timestamp, the sender and the receiver of the transaction, previous hash and information about the transaction.

Hash: A type of encryption that is irreversible. The result from a hash function.

Nodes: A computer that is connected to the blockchain network.

Private key: A user's private cryptographic password for blockchain access.

Public key: A user's cryptographic address to other blockchain users to access the user.

Nonce: "Number only used once", a random or pseudo-random number used in the mining process of Bitcoin to ensure that old communications cannot be reused in evidential attack.

1. Introduction

This chapter will introduce the reader to the underlying issues that lays ground for the study by explaining the background and the research gap. The background theory will be followed by the aim and the research questions generated from the research gap. It will also explain the limitations and the context of the study.

The world is facing a number of sustainability challenges. These challenges require that everyone is taking responsibility to contribute to making a more sustainable society that take future generations into consideration. Due to the increasing distances the food is traveling, from producer to consumer, keeping the food safe and at good quality is a big challenge (Chen et al. 2013). One of the Sustainable Development Goals, developed by the UN as a call to act on the major challenges in the world, aims to "ensure sustainable consumption and production patterns" and suggests that to ensure reduced resource use all actors within the supply chain needs to take responsibility. The food sector is responsible for 30 percent of the world's total energy consumption, 22 percent of the total greenhouse gas emissions and 1,3 billion tons of wasted food every year. The resource use is massive and still 1 billion people in the world are not getting enough food to eat (United Nations 2017).

Food waste is due to several causes, including lack of food safety management (Gustavsson et al. 2011). As a consequence to several food safety scandals in the recent past, the consumer awareness has increased. With 819,3 billion tonnes of milk produced in 2016, it is one of the most produced agriculture products in the world. Being that large of an industry, the sector poses risks of being exposed to food safety scandals (FAO 2017). In 2008, a milk related scandal broke out in China, with milk contaminated with melamine. The scandal led to 6 dead infants and 300 000 sick babies. The entire industry in China was affected by a decrease of 80% of the consumption (Pei et al. 2011). In 2013, a food crisis broke out in Serbia because of the findings of a toxin in milk products. The crisis was widespread and lasted for almost two years (Smigic 2015). In January 2018, there was an outbreak of salmonella in the products of powdered baby milk from one of the world's leading dairy groups which resulted in a product recall of 12 million products and 83 countries being affected (Willsher 2018). Most recent major food scandal, in March 2018, was an outbreak of Escherichia coli (E. coli) which was found in romaine lettuce. In the course of a month the outbreaks where recorded in 29 of the American states, causing 1 dead and 149 sick people (Manning 2018). The causes of all the food scandals are set to several but they all have in common to be caused by low transparency in the supply chain and inefficient batch sorting leading to lack of traceability (Jia et al. 2012; Qian et al. 2011; Pei et al. 2011; Chen et al. 2013). SDG says that a collaborate solution has to be found in order to obtain sustainable supply chains (United Nations 2017). As a response to the outbreak of E. coli, the lack of transparency within food supply chains are proposed by the responsible wholesaler to be solved by the use of blockchain technology (Manning 2018).

1.1. Traceability

According to the EU's general Food Law, traceability one step forward and one step back is required for all food and feed businesses. Further, it is obligated to rapidly provide this information to relevant authorities if necessary (EC 2007). Food scandals has moved the whole food industry to consider the safety and quality of the products as the primary requirement before it reaches the end costumer (Narsimhalu et al. 2015). The challenges outlines both by physical impact on the products and trustworthiness about the product (Chen et al. 2013). Thus, there is a need for a supply chain widespread traceability system to assure the correct link between the flow of the products and information to secure that the complete history can be restored if needed (Pizzuti & Mirabelli 2015; Narsimhalu et al. 2015). The European Commission (2016) recently made a vast report about the food and drink industry in EU pointing out the relatively high level of traceability and transparency, which provides competitive advantages for European companies. However, Njage (2018) says that there is a big variety in the way risk management is practiced in small scale-diaries and that they are likely to lack in their quality assurance. Allata et al. (2017) identifies that the implementation of a traceability system in addition can be used for quality assurance. A collaborative traceability system with continuous monitoring would lead to better control over the supply chain and product quality as well as enable faster detection of source in case of for example contaminated food issues (Pizzuti & Mirabelli 2015; Narsimhalu et al. 2015). A higher level of transparency and traceability can, except from meeting the customers demand, also provide better tools for planning and forecasting, and subsequently make greater profits (Heyder 2012). However, small and medium scale companies recognise the costs associated with the implementation of tracking technology as a barrier (Allata et al. 2017).

1.2. Trust

Consumer awareness is increasing due to an information asymmetry where companies fail to communicate with stakeholders (Wognum et al. 2010; Sarkis et al. 2011). The scandal of the contaminated milk in China during 2008 has left domestic brands to be mistrusted by consumers and opened up for greater import of international brands to dominate the Chinese baby powder market (Hancock 2018). Information systems and technology can enhance information exchange, there are still uncertainties regarding the guarantee of the integrity of information (Trienekens et al. 2012). To deal with the trust issue problems, regulations by governments (Pizzuti & Mirabelli 2015) and standards and certifications have been established by third party organizations, founded by organizations with shared interests (ISO n.d.a; GS1 2018a).

1.3. Infrastructure

A supply chain can be seen as a set of multiple actors connected as both buyers and suppliers by logistic services to provide a product to the end customer (Auler et al. 2017). The FSC generally starts at agricultural producers and suppliers, moves through a manufacturing stage and retail activities and ends with the consumer (Akkerman et al. 2010). Infrastructure in this study refers to the processes and support for information flow and business planning.

To fulfil regulations, standardizations and certifications, the industry continuously implements traceability systems based on Internet of Things (IoT) technology as support. IoT is based on machine-to-machine communication and enables to obtain cost reductions, efficiency, transparency and traceability (Haddud et al. 2017). According to Abeyratne and Monfared (2016), blockchain technology provides several advantages including durability, transparency, immutability and process integrity and has the potential to be applicable in and provide benefits to the manufacturing supply chain by improve product tracking and controlling of product quality.

1.4. Blockchain

Blockchain is an open, distributed and decentralized verification system for digital transactions where data about the transaction is stored in so called blocks which forms a chain in a network. A blockchain can be used to ensure the origin and authenticity of a product. All transactions, and each of the blocks in the chain, can be identified as an encrypted piece of information. Anyone connected to the network can add information in the blockchain if everyone in the network verifies the transaction, but no one can change or delete it without authorization (Abeyratne & Monfared 2016; Nationalencyklopedin 2017). Lin et al. (2017) proposes using blockchain as a basis for food traceability systems to meet the challenges with recent food scandals and raised awareness, and Kim and Laskowski (2017) says that blockchain holds the promise to provide transparency and traceability to inefficient business practices.

Several pilot projects have been carried out investigating the possibilities for blockchain to increase traceability within supply chains. Where inefficient methods for handling of information is an issue, causing both time, money and trust issues, blockchain has been proven to improve the tracking processes resulting in faster handling times. Tracking processes were improved from taking several days to a few minutes (Bajpai 2017). As for potential food crisis, the faster tracking opportunities could not only be preventing public health issues but also obtain cost effectiveness for retailers (Yiannas 2017).

1.5. Purpose, aim and research questions

It is shown that food scandals are an ongoing global problem, where dairy products can cause a lot of damage to vulnerable groups like babies. The scandals are a result from a lack of transparency and traceability within the FSC, leading to trust issues among different stakeholders. Blockchain is an immature approach under investigation, hence there is a need to mature theory and designs for the technology to find best fit standards (Saberi et al. 2018). Further, Walker (2018) calls for a tool and a framework that enables transparency and information flow between stakeholders within a supply chain to ensure trustworthiness and meet the lack of consumer trust.

This study aims to investigate the possibilities and challenges with implementing a blockchain framework as a solution for the transparency and traceability issues that is faced in FSC's. In order to investigate this, a case study approach is selected looking into a supply chain for milk.

In order to fulfil the aim of the thesis, three research questions (RQ's) are conducted. RQ1 is important in order to understand the current situation of the dairy supply chain. The findings and answers to RQ1 are used as a foundation to answer RQ2. RQ3 connects RQ1 and RQ2 in another dimension, discussing the possibilities and challenges of an implementation of a blockchain supported framework.

The following RQ's are derived from the aim of the master thesis.

RQ1: *How is the current supply chain of dairy products set up and what variables are tracked and traced?*

RQ2: *How could a blockchain supported framework look like applied on a supply chain of dairy products to enable track and trace management?*

RQ3: *What are the challenges and possibilities with an implementation of a blockchain supported framework for traceability in a supply chain of dairy products?*

The single case study is done in collaboration with a consulting company located in Karlstad, Sweden. The researched case outlines by one of the consulting company's customer referred to as the wholesaler, which also includes the retailer. The other two members of the supply chain, the dairy manufacturer and the distribution company, is locally seated in Värmland, Sweden. This master thesis has limited the food supply chain (FSC) to a part of the supply chain of milk including the dairy manufacturer, the distribution company and the retailer.

1.6. Structure of the Master thesis

The rest of this master thesis is structured as follows; *Chapter 2* will be outlined by the theoretical framework including explanations of relevant terms and concepts related to the aim and research questions of the study. *Chapter 3* presents the methodological framework and issues how the study has been conducted as well as the analysing process and the theory behind the choice of method. This chapter will also discuss the ethics and trustworthiness of the study. *Chapter 4* answers and discusses RQ1, *Chapter 5* answers and discusses RQ2 and *Chapter 6* answers and discusses RQ3. *Chapter 7* wraps the study together in a conclusion, managerial implications and suggestions for future research.

2. Theory

This part of the study presents the current research and concepts within traceability, trust and infrastructure in food supply chains. Lastly, this chapter will explain the concept of blockchain technology and discuss its benefits and challenges it faces.

2.1. Traceability

Traceability within the food sector refers to "the ability to track any food, feed, food-producing animals or substances used for consumption through all stages of production, processing and distribution" (EC 2007; ISO 22005, 2007). In practice this means to record information from all stages in the FSC about the product (Swiss Federation 2017). Traceability encourage collaborations and allows for complete transparency within a supply chain and the opportunity for companies to operate in a sustainable way (Swiss Federation 2017). For an organization, it can be either mandatory as legislated by the EU, or optional to provide food traceability data. Mandatory data includes information such as product ID, supplier and buyer ID, product description, lot number, quantity and unit of measure. Optional data is for example contact information, dispatch and receipt date, packing date, transportation vehicle and logistics provider ID and specific origins. Mandatory data are many times not enough to secure quality and safety of a product. Because of certain product specifics being optional it is difficult to gain full traceability of a product (Bosona & Gebresenbet 2013; Pizzuti & Mirabelli 2015).

Almost all regulations regarding food are composed within EU and are applied for all EU member countries in order to protect public health. Additionally, in Sweden the Swedish law of food (SFS 2006:804) and Swedish food regulations are complementing the EU's regulations (Livsmedelsverket 2018). Regulations states that a member of the food chain is responsible to provide tracking information and proper labelling for all substances within their products as well as where the product is to be further delivered in the chain. For the traceability purpose, every member of the food chain should have systems implemented that enables the food company to provide traceability information to the governments. Members of the food chain are responsible to immediately report to appropriate authority if they believe there is a risk to public health from their food (EC 178/2002).

2.1.1. Transparency

Transparency is predicted to become increasingly important in the future as the stakeholder awareness is increasing, which has a direct impact on consumer trust and a company's sustainability performance (Mol 2015). Transparency and traceability are closely related, where traceability can be seen as a vertical dimension of the transparency in a FSC. Traceability enables to follow a product, and the process it undergoes, which leads to more transparency. Hence, it is making it possible to offer specific, required information to different actors and stakeholders without loss, noise, delay or distortion (Wognum et al. 2010). Transparency in a FSC is enabled by the application of food quality and safety standards, information exchange and supply chain governance mechanisms (Trienekens et al. 2012; Pant et al. 2015). The motivation for implementing transparency into a supply chain is shown to be higher if it is equal to a certification than adding a traceability system within a supply chain in order to obtain higher level of efficiency and information sharing (Sellitto et al. 2018). Thus, a certification will generate direct consumer value and is supported by profitable motivations (Stranieri et al. 2017). Further motivators for a higher transparency and the implementation of traceability system are found to be the following; regulatory, food safety, food quality, social, economic, technological, collaborative information exchange and efficiency (Bosona & Gebresenbet 2013; Stranieri et al. 2015; Trienekens et al. 2012).

2.1.2. Food safety

Given several food scandals and the case of perishable food products, such as dairy products, product recalls have become a key challenge when dealing with food safety, as for why governments and organizations has given it more attention. The food scandals have indirectly forced suppliers to apply costly assurance systems to be able to ensure safe food and meet market demands (Kotsanopoulos & Arvanitoyannis 2017; Pant et al. 2015). Distribution networks have to be designed in a way that acts appropriately in case of a product alarm to promote rapid identification of scale and cause, reduce expenses, reduce the exposure to final consumers and increase trust. The wholesaler must therefore be well prepared to conduct product trace-backs and withdrawals (Akkerman et al. 2010; Allata et al. 2017).

When information about a process is not linked to a traceability system there is a risk of information loss. Karlsen and Olsen (2011) developed methods for assessing this issue and identify these so called Critical Traceability Points

(CTP's). To validate traceability, it is important to target the CTP's and modify the process as well as enable the information to the rest of the system (Karlsen & Olsen 2011). Septiani et al. (2014) identified four categories of risks within a dairy supply chain; Supply risk, Disruption risk, Demand risk and Process breakdown risk. Pei et al. (2011) stresses that the main CTP in a dairy supply chain (DSC) is the milks temperature throughout all steps of its supply chain.

2.1.3. Food waste

Food waste is a major global problem causing not only economic consequences but also environmentally and socially (Scholz 2015). Thus, the further down the supply chain food is wasted, the more resources have been used and the greater the consequences. The awareness about this issue is generally stated to be growing in the EU (Quested et al. 2013) as well as globally (Gustavsson et al. 2011), meaning that it is of common knowledge to authorities that food waste imposes environmental damage at multiple levels and that a reduction is needed. Food waste may be a cause of many different factors and actors, as the issue involves all echelons within the FSC it requires actions and responsibility to be taken by everyone involved. It is stated that joint initiatives and acts to prevent and reduce this has to be undertaken and a systematic review of the awareness and knowledge amongst all different actors is crucial (Zhong et al. 2016; Radzyminska et al. 2016). Zhong et al. (2016) stretch the importance of data sharing and seamless synchronization of e.g. food production management systems and logistics management in order to deal with food waste.

Food waste occurring in the production of milk is relatively low compared to vegetables. Even though the food waste within the milk supply chain, excluding the consumer stage, only is 1,4 %, the waste of milk has a higher impact on climate, economy and land-use compared to vegetables (Tostivint et al. 2017; Franke et al. 2013).

2.2. Trust

Zhang et al. (2016) concludes that important elements in trust making is governmental power and their backup, strong brand names and standards and certifications by Non-Governmental Organizations. The study also stresses the importance of delivering the information in a simple and creditable way which in turn causes challenges for the data providers.

Transparency can enable and enhance trust in relationships which in turn increases performance, synergies and overall success. However, the level of trust is intangible and hard to measure, unlike profits, hence the incentives must be clear for all parties in order to apply transparency measures like blockchain technology (Hua & Notland 2016). Overall quality management systems can be improved by increased traceability because of the increased communication it provides. With increased traceability, sources of noncompliance can be identified and investigated and the communication linkage it provides can also agree with standards and customer expectations (Pizzuti & Mirabelli 2015).

For companies who are unable to build a company-owned supply chain they can develop a "supplier code of conduct", utilizing supplier certification programs or enforce high quality standards that are strictly monitored and controlled, to establish strong partnerships and exercise vertical control in the chain. Under certain conditions, in decentralized systems there is a risk of distortion in product quality, for example when a profit-maximizing supplier tries to take advantage of the situation or when a supplier's profit is squeezed. An important component in creating an integrated FSC system for food control is to create a culture that encourage active participation by everyone in the company, including the employees (Chen et al. 2013).

2.2.1. Consumer awareness

As an effect of the increasing consumer awareness (Aung & Chang 2013; Wognum et al. 2010), companies within the food industry now need to inform about aspects like the origins and processes of food procurement, safety, quality, production methods, environmental issues in an extended way. Traceability is expressed to be the act of visualising and informing about these aspects, which will increase and satisfy the consumer confidence. Many of a supply chains problem are related to communication, where trust building is to be emphasized through informational visibility and verification (Kshetri 2018; Chen et al. 2013). As the difficulties of accomplishing traceability and transparency lies in the act of cooperation and collaboration between actors, prior research calls for concentrating the questions around creating greater collaboration and information sharing between actors in the supply chains. Subsequently companies need to increase their CSR and sustainability work to achieve better collaboration and transparency (Mol 2015; Narsimhalu et al. 2015; Wognum et al. 2010).

The lack of information about food processes is due to their compellability. Furthermore, it is not only the technological collaboration that has to be improved, the human collaboration is facing cultural diversities, different expectations from stakeholders and varying openness in organizations (Kaloxylos et al. 2013). It might not always be entirely easy to meet the requirements of increased communication since a company may lack full knowledge about the product, materials, information or the processes flowing in the supply chain. This situation refers to information asymmetry and results in limiting the consumers understanding of the social and environmental implications of their consumption decisions (Sarkis et al. 2011; Sayogo et al. 2015). Greater interactions within the supply chain would reduce the information asymmetry. Firms with great power and overall close relationships has a greater chance of collecting information and lessen the information asymmetry. It is proposed that distance; physical, social or cultural, is correlating with increased information asymmetry. The distance is creating communication problems, hence the more global the supply chain is the more likely this is to occur. In case of high information asymmetry with stakeholders, organizations can apply the theory of signalling. The theory suggests mechanisms to resolve the asymmetry by for example certifying their practices, which sends a signal to the stakeholder (Sarkis et al. 2011).

2.2.2. Standards & certifications

There are different kinds of standards for food safety and quality assurance which all share two common features; the reliance on documentation of production processes and practices, and third-party auditing and certifications (Kotsanopoulos & Arvanitoyannis 2017). The responsibility for food control in Sweden is divided between municipalities, country boards and Livsmedelsverket depending on the type of organization, having different responsibilities of food safety controls (Livsmedelsverket 2017). Livsmedelsverket has developed a number of guidelines for companies in the food sector to follow to serve as support to the EU regulations. One of the guidelines says that traceability can be obtained by documentation. The documentation could be in form of invoices, delivery notes or special forms providing information about the quality or variables such as temperature. The documentation should be stored in such way that it will be effective to find when required, for example in case of an audit. If the documentation is stored digitally there have to exist back-up routines (Svensk mjölk 2007).

To support and guide actors in meeting law and regulations several standardizations has been developed through history. Table 1 shows the most common used standardizations in a dairy supply chain. The International

Standardisation Organisation (ISO) is the largest developer of international standards in the world and is used to achieve uniformity and prevent technical barriers (ISO n.d.a). To achieve traceability, ISO have developed several standards fitted for a FSC, for example ISO standards addressing quality management performance, environmental responsibility management and track and tracing of documentations (ISO n.d.b; ISO n.d.c; ISO n.d.d; SIS n.d). Moreover, British Retail Consortium (BRC) is another international standardization developer, focusing only on the food sector (BRC Global Standards 2018). Lastly IP Livsmedel is a simplified standardization of ISO 22000 developed to fit small and medium sized food manufacturers. ISO 22000, BRC standards and IP Livsmedel are used for food safety and traceability, often enabled by using Hazard Analysis Critical Control Points (HACCP) guidelines (Kotsanopoulos & Arvanitoyannis 2017). HACCP is believed to play an increasingly bigger part in working with food safety and optimization as it can provide actors along the supply chain with information for better performance. As the data collection from sensors placed in the FSC is getting richer and may report real-time data, there are possibilities for more accurate analysis with a HACCP system implemented (Vanderroost et al. 2017).

As a support to the documentation and traceability, Global Standards One (GS1), has several standards of how to present and communicate information and documentation across the FSC (GS1 n.d). GS1 started as an organization in the US, working collaboratively with ISO certifications, to standardize product identification which later resulted in the GS1 barcode (GS1 2018a; GS1 AIBSL 2018).

The mentioned standardizations mostly operate between companies to obtain business flows, but there are also standardizations to validate the quality of a product and communicate it to the consumer. A commonly used standardization of this kind is KRAV (KRAV 2017).

Table 1: Table of commonly used standardizations in the FSC.

Certificate or standard	Explanation
ISO 22000	Addresses requirements for food safety management and traceability system, including the whole supply chain by encouraging communication upstream and downstream in the supply chain (ISO/TC 34/SC 17 2018).
ISO 9001	Addresses principles for quality management with a customer focus (ISO n.d.e).
ISO 14001	Provides organisations with a framework to perform environmental management system (ISO n.d.d).
ISO 39001	Determines requirements for Road Traffic Safety (RTS) management system to be able to communicate with road traffic systems in order to reduce accidents and deaths in traffic (ISO n.d.f).
HACCP	Guidelines with a preventive approach for good hygiene praxis to prevent food safety hazards, with the ability to be applied in all operative processes of a FSC as a tool for self-monitoring (EC 852/2004; Kotsanopoulos & Arvanitoyannis 2017).
GS1, ESAP20	Electronic Data Interchange, EDI, is a commonly used electronic transfer standard, the format of the data is collaboratively standardized for information flow between organizations (Lindholm 2018). ESAP20 is a standardisation of EDI developed by GS1 covering standardisation of information flow and information sharing between members of a supply chain in the order processing, from pushing an order to the receiving and confirming the delivery of an order. (GS1 2018b).
KRAV	The most common certification for eco-labelling in Sweden taking special consideration to and with particularly high demands on animal care, health, social responsibilities and climate impact. It is following the EG directions for organic production but is in some cases stricter than these (KRAV 2017).
BRC	British Retail Consortium (BRC) aims to give retailers legal, financial and technical advantages as well as to protect customer health (Kotsanopoulos & Arvanitoyannis 2017).
IP Livsmedel	IP Livsmedel is a standardisation for small and medium enterprises in the Swedish food industry with the aim to serve as a simplified and cheaper version of ISO 22000 and BRC (Hoolmé 2012).

2.3. Infrastructure

The overall lack of transparency and adaptation of IoT-technology in the sector, to increase the level of transparency, is believed to be linear with high costs. The effects are due to the complexity of several technologies and systems to collaborate regarding continuous updates and service (Kaloxylos et al. 2013).

2.3.1. Information flow

Information flow refers to the path of information through a supply chain and is an important part of business administrations since an efficient information flow aims to, among other things, cut costs. With a lot of information and a lot of receivers and respondents in a network, an information flow easily gets complex. Information can be transferred vocally, through physical paper documentation or electronically (Lindholm 2018).

To enhance information flow in a FSC the supply chain network should create support for information transparency by enabling information exchange and sharing between each other (Pant et al. 2015). The appearance of missing documents is resulting in big costs for distribution companies, many of them believe that electronic documents instead of physical could solve the problem (EC 2017). By the use of IoT, the manual transactions can be transferred to digitized information flows where technology enables organizations to increase efficiency and sustaining competitiveness by digitizing external networks and reducing internal management costs (Korpela et al. 2017).

2.3.2. Traceability systems

To hold down costs and damage and optimize a FSC, it is crucial to obtain good practice of traceability and recall management by having an efficient traceability system. A traceability system provides support for data access for supply chain members and good quality management practice. It outlines by the collection and storage of product specific information about safety and quality connected to a products journey through a supply chain including where the product has been processed, packaged and distributed (Dabbene et al. 2014; Xiaoshuan et al. 2013; Allata et al. 2017).

Wang and Yue (2017) proposed a food safety pre-warning system utilizing already existing IoT-technology to help managers in FSC's to detect food safety risks as well as increase communication and information sharing in the FSC. The results showed that a system like the one presented in the study led to more efficient decision making, effectively identified safety risks, minimized the production and distribution of unsafe or poor-quality products and limited the damages associated with product recalls.

Traceability systems and sustainable management

Boyd et al. (2007) highlights that several studies has been made to prove the benefits of a collaborative approach. The vision of shared information is believed to lead to competitive advantages, a better CSR, risk sharing, efficient performance and an understanding among actors within a supply chain. As for the decision making, it becomes more transparent, ethical and unbiased.

The role of product-centric information management and interoperability between devices will become more important in the future in terms of utilizing assets and resources effectively by the society (Mattila et al. 2016).

Traceability systems and Internet of Things

IoT is based on machine-to-machine communication and its structure is built on three layers; the perception layer, the network layer and the application layer. These layers relate to sensing, data transfer and data storage, and manipulation respectively. IoT is providing real-time visibility to the flow of materials and products, hence transforming and optimizing different business processes as well as providing flexibility. An implementation of IoT in a supply chain have the potential to provide several benefits such as cost reductions, effectiveness, transparency and traceability. Despites the many benefits of IoT, there is a downside in the continuous data flow that has to be stored, analyzed, synthesized and presented (Tzounis et al. 2017; Haddud et al. 2017). IoT devices are, despite the fast development, still too insecure and incapable of defending themselves against attacks due to immature standards and the lack of secure enough hardware and software design (Kahn & Salah 2018). Furthermore, the key challenges of implementation are identified to be the lack of knowledge within the organizations, the lack of knowledge of the cost benefits and the investment costs (Tzounis et al. 2017; Haddud et al. 2017).

Due to embedding communication and the decreasing prices of storage and computing technologies in devices, the implementation of intelligence has been made possible into all types of products including non-durable, such as milk. A general trend in the market of non-durable products, is the repositioning of competitive advantages all around the economy using new digital technologies resulting in complicated competition environments (Mattila et al. 2016).

There have been many researchers proposing different models or frameworks for enabling and improve traceability in the FSC. Many studies have been made considering traceability systems based on RFID-tracking (De Las Morenas et al.

2014; Tian 2016; Wang &Yue 2017). Further, Pant et al. (2015) and De Las Morenas et al. (2014) proposes adding GPS-technology for location tracking and Arcuri (2013) developed a DNA barcoding system. The studies all have an approach of collecting and sharing data in the supply chain. As many companies currently are developing real-time data monitoring, the data is proposed to be handled by standardizations such as ISO for an effective traceability management and enable further development of traceability systems to be used as pre-warning systems (Gianni 2017; Wang & Yue 2017).

2.4. Blockchain technology

Blockchain technology is based on a distributed ledger system and can be seen as a verification system for digital transactions where data about a transaction, between members of the network, can be stored. A blockchain can allow different levels of access; private, public or consortium and be outlined in different kinds of distribution architectures such as centralized, decentralized or distributed as further described in Table 2 and visualised in Figure 1.

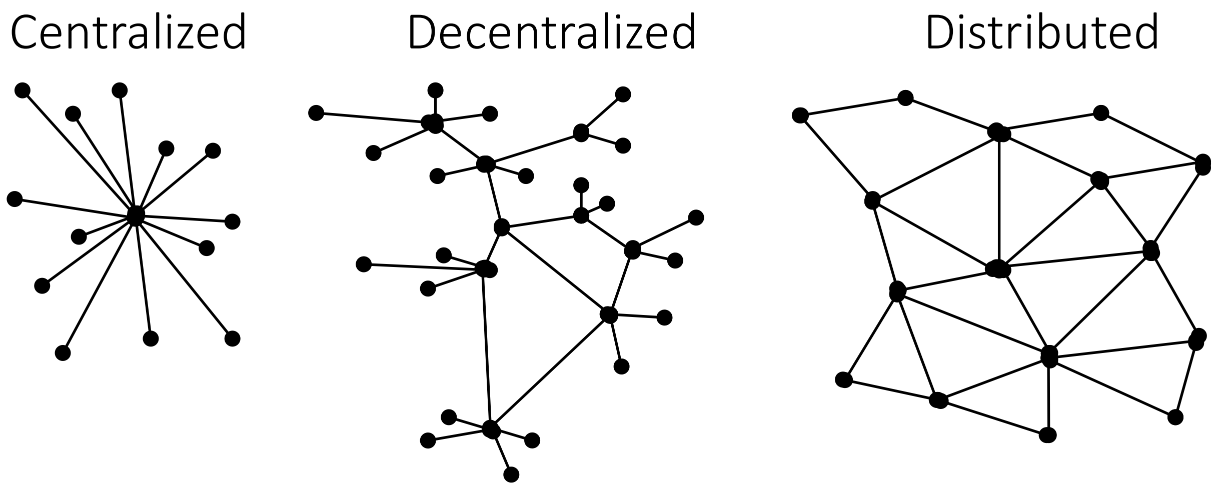

Figure 1: Different network structures.

A member of a blockchain network is often called a node. A block contains of a hash and the hash from the previous block, which is how the blocks are connected and data will be chronologically stored, forming a chain of blocks within a network. Each of the blocks can be identified as an encrypted piece of information where all transactions are encrypted by so called hashing. A hash is the result from a hash function of all the content inside a block. A hash function is an algorithm that encrypts data and is almost impossible to reverse (Abeyratne & Monfared 2016; Nationalencyklopedin 2017). The hash function is performed within some kind of consensus protocol which can be described as a specific procedure to confirm a transaction on a blockchain. The confirmation of transactions is an important function on the blockchain due to the risk of hacking attacks. A famous theory addressing the risks of attacks is called the Byzantine fault theory. The Byzantine fault theory originates from Byzantine generals' problem where several different armies together could defeat a city only if they all communicate at one specific moment and decide on the attack at the same time. This problem can be applied in the digital world, saying that one single node will fail with a hacking attack, but if a network of nodes collaborates at the same time they will be able to hack a database, or similar (Lamport et al. 1982). There are different approaches to deal with this problem, Table 2 describe the following three common consensus protocols in more detail; *Proof of Work (PoW)*, *Proof of Stake (PoS)* and *Practical Byzantine Fault Tolerance (PBFT)*. Further on, to be able to perform a transaction, the nodes are respectively provided with a private and public key which are further described in Table 2 (Kairos Future 2017). The consensus protocols are used to secure transactions, although they are severely time and energy consuming, why it has now appeared tools for optimizing the consensus processes, the most common, using a Merkle tree, is described in Table 2 an illustrated in Figure 2 (Investopedia 2018a).

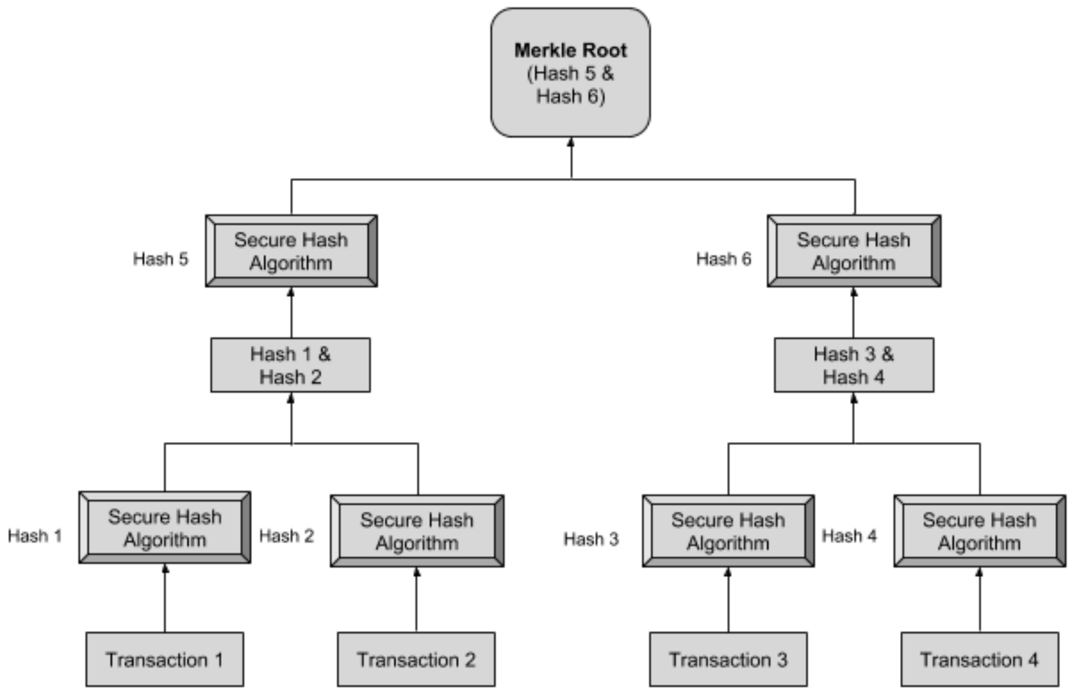

Figure 2: Merkle Tree using a Secure Hash Algorithm.

An important aspect to the blockchain technology is that it is designed to store information in a way that makes it impossible to change, delete or add information or blocks without being detected by other users. This ensures the origin and authenticity of the transaction and thereby also increase the overall transparency and trust when linked to a specific product. One of the characteristics of blockchain is that a blockchain network can agree on their own rules in the network without a third party (Abeyratne & Monfared 2016; Nationalencyklopedin 2017).

Table 2: Essential parts of blockchain technology.

Function	Type	Description
Access	Private	A private blockchain is under the control of one organization and the members are those who satisfy certain requirements and get assigned different authorities. A private blockchain is rather centralized.
	Public	A public blockchain is open for anyone to join the network anonymously, take part of the records and be part of the consensus process (Lin et al. 2017). A public bloc kchain can be seen as a distributed network.
	Consortium	A consortium model is a model based on the benefits of public blockchain framework but a kind of private chain with well-known actors, so called permissioned actors (Gramoli 2017). In some cases, a hybrid version of blockchain could be called consortium.
Keys	Private	A private key is only known and seen by the owner node of the key and are used for access to the network, the nodes account and transaction confirmations (Kairos Future 2017).
	Public	A public key can be seen as an address to the specific node, for other nodes in the network to interact with that specific node (Kairos Future 2017).
Distribution architecture	Centralized	A centralized network outlines by all data to be collected and stored in one single point (Larsson & Korsfeldt n.d; Lin et al. 2017).
	Decentralized	A decentralized network outlines by the data to be spread out globally to several local databases. The ledger content is agreed upon by all member nodes by using a consensus protocol
	Distributed	A distributed network outlines by a number of copies of data that is held by several nodes in the network. In the case of Bitcoin all nodes hold a copy of all transactions (Pehrson n.d).
Consensus protocols	Proof of Work	PoW is the consensus protocol used by e.g. the Bitcoin blockchain network. The confirmation process of transaction is made by performing a work-intensive task using information from the existing blockchain, called "mining". In the case of Bitcoin, a block contains of a nonce. The PoW process in the case of a Bitcoin transaction includes scanning for a value to be hashed. The hash begins with a certain number of zeros and the PoW outlines by a miner incrementing a nonce to the block until reaching less or the certain number of zeros. When a satisfying nonce is found, a hash difficult enough is found and the block can be added to the chain. When a miner has found a solution, that node will broadcast it for the rest of the network whom will accept the block only if all the transactions in the block are valid. The network shows their acceptance by start solving next block in the chain, using the hash from the accepted block. This is an extremely difficult, time and energy consuming process. (Investopedia 2018b; Investopedia 2018c; Ray 2017; Nakamoto 2008).

Function	Type	Description
Consensus protocols	Proof of Stake	PoS outlines by validators that "mints" or "forges". The chances of being the one validator to create and validate a block is linear with the amount of coins in their crypto wallet- the more coins in the wallet the higher the chance to validate. A wallets size compared to the networks value is the wallets stake. The bigger stake a validator has, the bigger chance it is to solve the puzzle. The validation process starts with the validator to put their wallet in risk to the network, when the wallet is set at risk they are able to approve a transaction. The one with the biggest stake will most likely win the puzzle. The validators get rewarded with transaction fees. If the approval of a minter or forger is not valid, the minter or forger will lose its wallet. (Cryptonaouts 2017; Simply Explained - Savjee 2018; Zheng et al. 2017).
	Practical Byzantine Fault Tolerance	PBFT is an algorithm that tolerates byzantine fault in an effective way. The nodes in a network are called *replicas*, where the used node is called *primary* and the others of the network are called *backup*. In order to confirm a transaction, the PBFT goes through three stages; pre-prepare, prepare and commit. The three stages are outlined as a message log. The algorithm starts with a client to send a request to a replica who then becomes the primary. At the same time the three-stage protocol starts. The pre-prepare stage is sent to the other replicas in the network without the actual request information included, in order to confirm that the request is valid. The backup confirms the pre-prepare stage and the prepare stage is triggered. The prepare stage is valid if it matches pre-prepare messages which is checked and confirmed by both the backup and the primary. Once confirmed it is added to the protocol log and triggers the commit stage. Replicas confirm the commit message and adds it to the protocol log. When the commit is confirmed a reply will be sent to the client. (Castro & Liskov 1999; Colyer 2015).
Optimizing	Merkle tree	A Merkle Tree is a data structure that in cryptocurrencies like Bitcoin is used to more efficiently and securely encode blockchain data. Instead of running the entire block of transaction data through the hash function, each transaction in the block is hashed and then paired with another transaction and hashed together, and so on until there is one hash for each block, called the Merkle Root (Investopedia 2018a). Thus, the Merkle Root is the resulting hash of all the hashes that has been made of all the transactions that has been done in a block, see figure 4. The Merkle root is updated every time a new transaction is accepted (Bitcoinwiki 2015). Merkle Trees are useful because verification of a specific transaction can be done without having to download the whole blockchain, instead verification can be done by only having to look at the associated hashes on each branch and the Merkle Root (Investopedia 2018a).

2.4.1. Smart contracts

A smart contract can be described as a software which can automatically trigger certain functions to take place when something predetermined event is happening. Figure 3 shows a possible smart contract interaction with the blockchain, the requirements are stored in "contracts" and have to be fulfilled by the users to enable the creation of a new block. A smart contract is not a part of the blockchain protocol itself, but a feature performed on the blockchain which is stored in a completely distributed manner on a blockchain database (Mattila et al. 2016).

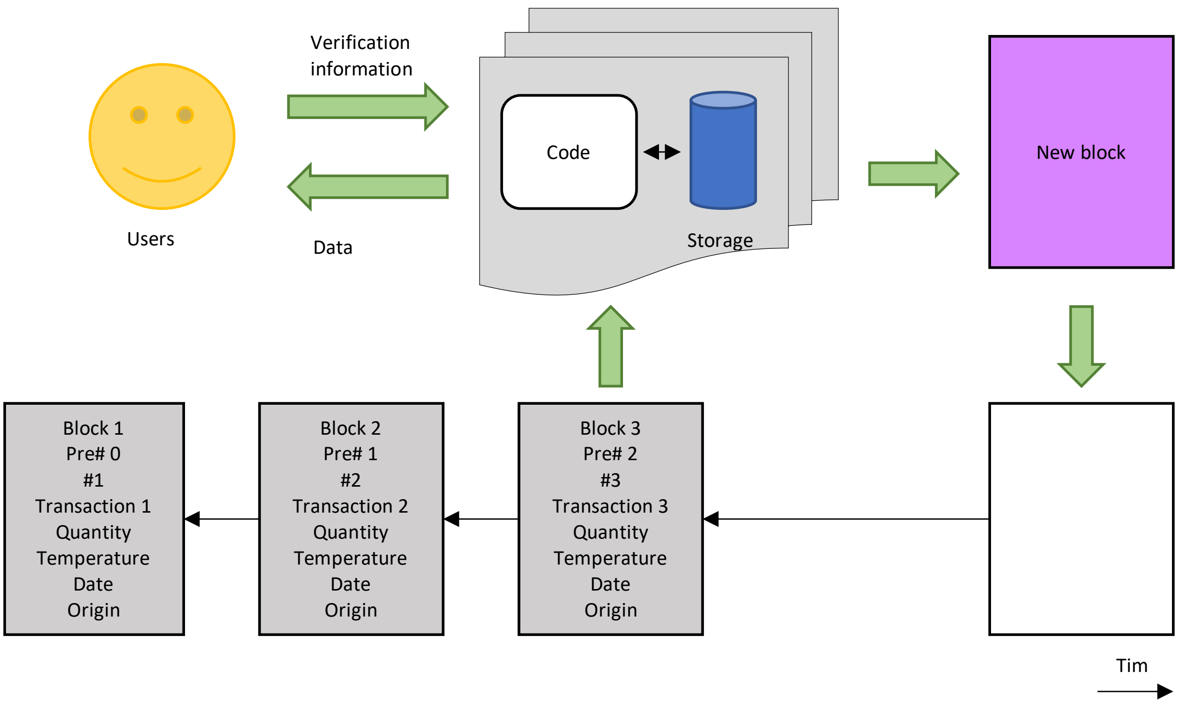

Figure 3: Example of a process for smart contract.

2.4.2. Benefits and challenges

According to researchers, blockchain provides several advantages and opportunities. A centralized supply chain system has, until the discovery of blockchain, been the most practical way to achieve transparency and data security. The risk of an organization to become the weak link and single point of failure is one of the issues having a centralized system (Abeyrate & Monfared 2016). In a centralized supply chain traceability system, supply chain members rely on one single information provider to store, transfer and share all information. This centralized system approach imposes problems as it is a monopolistic, asymmetric and non-transparent information system approach which can result in trust issues, fraud, manipulation and falsifying of information among the actors within the supply chain (Tian 2016). In a distributed system however, the hash functions make the framework resistant to hacking attacks. Due to the securely saved data, a blockchain enables the possibility of maintaining immutable information about a product, enabling stakeholders trusted information in order to act in a more sustainable way (Saberi et al. 2018).

But, if the framework outlines by a decentralized network with only a few actors facilitating the system, the solution gets vulnerable to attacks by hackers who can target a few members (Kshetri 2018).

However, the technology is an immature technology in its initial phase facing barriers regarding scalability in terms of throughput, latency and capacity (Lu & Xu 2017; Tian 2017). The technology enables global collaborations, which requires satisfaction of regulations, laws and commercial laws worldwide and making the implementation of blockchain to a complex project. Furthermore, there will always be a distance between physical environment and the virtual, allowing for failure in the trustworthiness by enabling the opportunity for an actor not to fulfil the actual and physical action as they promised in a digital contract (Kshetri 2018; Lin et al. 2017). Smart contracts could be implemented and embedded into the system to provide incentives to enable blockchain to govern progress of a business process and further streamline and automate supply chain processes. Smart contracts can lower cost and raise the assurance by reducing the amount of human involvement to manage a contract (Abeyratne & Monfared 2016). To make the blockchain work effectively it requires all parties to agree, which can be a hard task to manage. Not only does the actors of the supply chain have to agree on a common solution, often many supply partners are located within developing countries, making the step for integration of blockchain far away (Kshetri 2018).

The technology allows a for high levels of immutability, process integrity and transparency within the supply chain, and when being connected to IoT-devices it is also able to provide high support to a traceability system to work efficiently. As the framework provides increased business to business integration by enabling a high level of information sharing, it makes it possible for organizations to gain a deeper understanding of the supply chain they are a part of which enables to improve marketing, sale, logistic and product quality activities (Abeyratne & Monfared 2016; Kshetri 2018; Khan & Salah 2018; Tian 2017). Those activities make it possible for smarter prognoses that saves recourses, ensuring social responsibility and as an outcome saving money of the processes and further on encourages to act more sustainable (Saberi et al. 2018). As the blockchain technology enables efficiency improvements by e.g. being able to eliminate paper records and replacing it with real time data, it will further enable cost savings due to time savings (Abeyratne & Monfared 2016; Kshetri 2018).

As for a blockchain being implemented in a distributed network it can cut third parties involvement such as finance services of banks or certification services (Korpela et al. 2017). On the other hand, the use of blockchain can simplify for third parties, such as governments and certification organizations, to do check-ups on data and thereby govern their certifications (Tian 2017).

Although the data has to be collected by IoT-devices and linked to the blockchain (Saberi 2018), the blockchain itself does not require any additional equipment like hardware devices, which allows the data to be cost effectively recorded and stored. Blockchain can store data on unit level which makes it possible to track every single ingredient to its origin even in complex foods (O'Marah 2017). Further, the blockchain technology requires a certain IT-infrastructure in the supply chain, such as access to the internet, which may be impractical at the moment for some remote providers of raw material. The digital profiles would need to be kept updated constantly through manual or automated systems such as simple or RFID tags (Abeyratne & Monfared 2016).

Blockchain is expected to have the opportunity to solve some of the challenges involving ownership and identity relationships of IoT-devices used in the industrial sector by providing trustworthy and authorized identity registration and ownership as well as tracking and monitoring of goods, product and assets (Khan & Salah 2018). The blockchain technology also provides benefits to the consumer, allowing them to access specific and accurate product data (Abeyratne & Monfared 2016).

3. Methodology

The following chapter intends to clarify the research methodology used in the study. This involves an explanation and justification of the methods used and the process of collecting and analysing the empirical data. Furthermore, it will discuss the ethical aspect and trustworthiness of the study.

3.1. Research design

The theoretical framework was developed through an iterative process collecting data by performing interviews and literature reviews as well as from mapping, analysis and calculations. It has its perspective in the case study and canalizes down to the four head concepts shown in Figure 4; *Traceability, Trust*, *Infrastructure* and *Blockchain*.

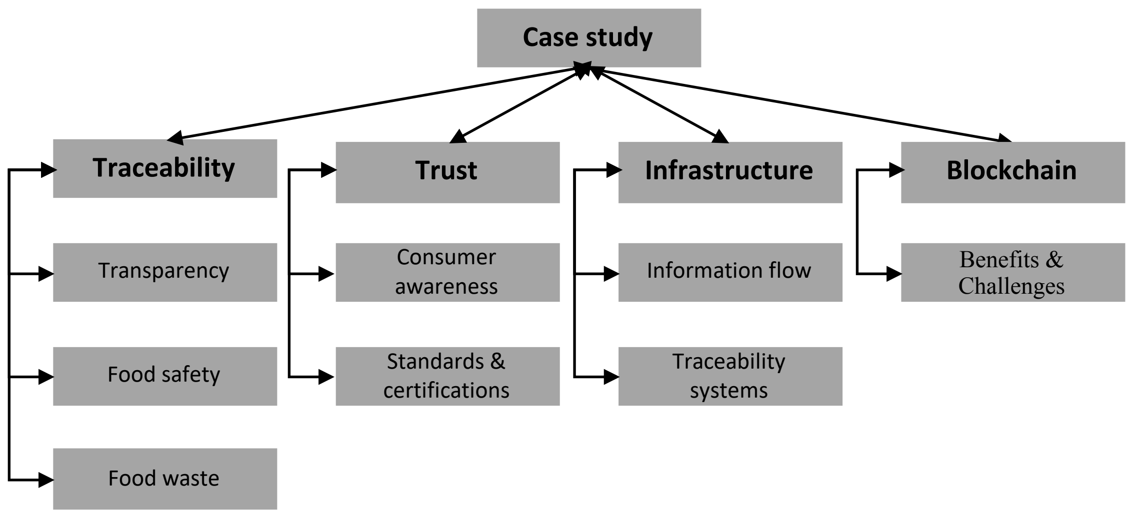

Figure 4: Illustration of the theoretical framework based on the case study.

There was a qualitative data collection approach applied to the research in order to get the holistic view of the case study situation. It was preferred to get in contact with the context in its real life setting to get a full understanding of the possibilities and difficulties in doing strategic changes in the supply chain. To get the right interpretations of different actors' attitude, interviews with additional observations were chosen as the qualitative data collection method (Gray 2017).

An explorative study aims to answer questions of how and why, hence the study has an explorative approach since the aim of the thesis is to understand how blockchain can serve as an overall framework for increased traceability and transparency by gathering data through interviews and by doing literature research (Gray 2017).

As a support to the analyses and the findings in theory and the empirical data, calculations were made to provide another dimension and strengthen the results discussing the possibilities in increased traceability for a blockchain supported framework in case of a product recall. The calculations were made based on empirical and theoretical data, focusing both on costs and CO_2-footprint.

3.1.1. Case study

Table 3 was used to evaluate the best fitting method depending on the research questions and the aim. According to Yin (2009) there are three questions to be asked when deciding on the method; what category the research questions belongs to (who, what, where, how or why), whether the research requires control of behaviour, and if the focus of the study is contemporary or on historical events. Since the focus of this study was not on historical events but investigated current events, required no control of behavioural events as well as the research questions were of how-type, a case study approach was considered the most suitable method to use (Gray 2017).

Table 3: Overview of when to use different research methods depending on three main questions (Yin 2009).

Method	Type of research question	Control of behavioural events required	Focuses on contemporary events
Experiment	how, why?	yes	yes
Survey	who, what, where, how many, how much?	no	yes
Archival analysis	who, what, where, how many, how much?	no	yes/no
History	how, why?	no	no
Case study	how, why?	no	yes

The single case study approach was further considered to be well suited due to the restricted time perspective of the study, at the same time as it was considered enough time to be able to apply theory into a real context and evaluate it (Yin 1994). There is a lack of research done within the research area which further supports the choice of a single case study since it provides insights in a specific context that can add to the research field (Gray 2017). The single case study allowed an in-depth understanding of the theory in the physical and empirical context (Yin 2004).

3.2. Systematic combining

A systematic combining approach was utilized in the study. A systematic combining approach is described by Dubois and Gadde (2002) to advocate a non-linear and non-positivistic research process with the objective to match theory and reality. The approach refers to an intertwined research process going back and forth between theory, framework, empirics and case analysis to fit these together as the process moves on. This way, the theory development can be extensive as all activities evolve simultaneously. The process is illustrated in Figure 5. As this study was exploring an immature technology it was difficult to tell, from a first observation of the subject, what sub themes that would be of importance to the study. The research started with identifying the research area and to find a suitable research case. A literature review was conducted to develop a theoretical foundation on which the qualitative data collection was initially based on. The data from the empirics complemented the theoretical foundation and provided insights into additional areas to be investigated within the framework of the study. The iterative process was continuous throughout the study until a research discovery was made evolving into answering the RQ's and forcing the researchers to evaluate the relevance of theory and the direction of the study. Hence, theory was developed iteratively due to findings in empirical data which were iteratively analyzed, matching theory and empirics with the investigated case study in order to finally conclude insightful and relevant research findings (Dubois & Gadde 2002).

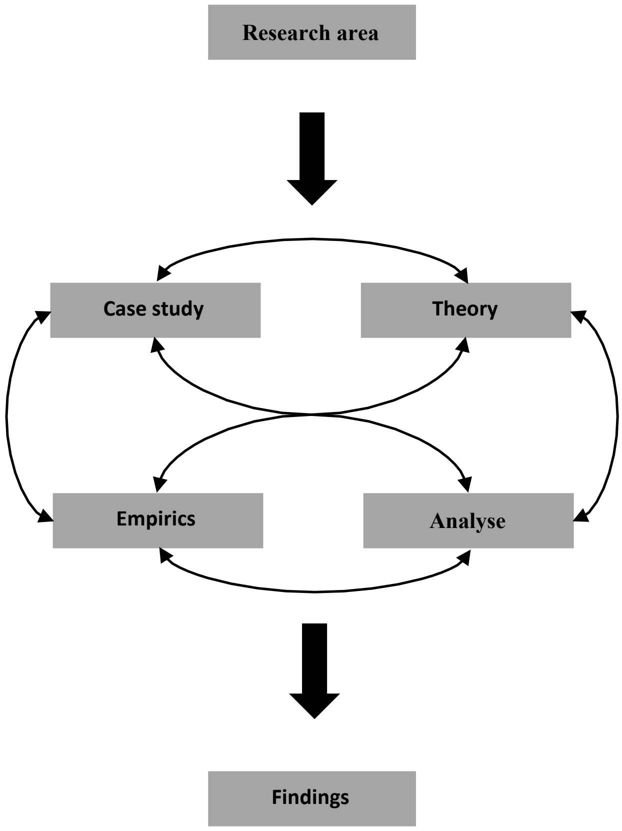

Figure 5: The Systematic combining approach.

3.2.1. Literature review

A literature review was done to provide basic understanding of the conceptual settings of the study and identify gaps in current studies. The main databases used to gather literature was *Onesearch* and *Google scholar*. The reviewed literature has primarily been peer reviewed articles in order to eliminate information that might not be reliable, trustworthy or biased. In addition to this, newspaper articles, blogs and YouTube videos were investigated and look at to complement the understanding.

3.3. Method of data collection

The study was using a qualitative method of interviewing with additional observations for empirical data collection. The findings from the empirical data were iterated with theory according to the systematic combining approach.

3.3.1. Interviews

The empirical data was collected through ethnographic inspired methods, combining semi-structured interviews, observations and expert interviews (Gray

2017). Semi-structured interviews were chosen as it has a clear outline with some main subjects and questions, leaving room for follow up questions and for the respondents to explain their answers, and build on their answers (Saunders et al. 2009). Because the interviews with the supply chain actors were made on site and photos were taken in order to assist the researchers' memory and assure that the correct perception about the physical reality of the business processes had been made. Additional expert interviews were made to gather complete understanding of the researched supply chain.

Sampling

With the help from the consultant company a brief outline of the research case supply chain could be mapped. Based on the theoretical mapping of the supply chain, desirable respondents could be identified, hence the sampling was non-random. There were two groups of respondents identified to cover the scope of the theoretical framework. One group aimed to cover knowledge about the current state of the supply chain of milk products and the other group to cover knowledge about the blockchain technology challenges and opportunities within the case scope. Desired respondents for the first group were CEO´s or site managers within the investigated supply chain with holistic as well as in-depth knowledge of the organizational operations. The other group was represented by external experts in traceability systems not working directly in the supply chain. The final setup of respondents can be seen in Table 4.

Semi-structured interviews

Semi-structured interviews were conducted with the purpose of making it possible to find unpredictable data. There were two different interview guides made, see Appendix 2, Interview guide A and Interview guide B. Interview guide A aimed to answer the current state of the milk supply chain and Interview guide B aimed to answer the potentials and challenges with an implementation of a blockchain to the case specific supply chain. The interview guides started off with control questions of biographical nature which followed with questions based on the theoretical framework. They were created to make sure the same questions were asked, but still leave room for unexpected answers, follow-up questions and interpretations (Gray 2017). The interview guides were reviewed by a supervisor at Karlstad University.

Before the original interviews started, a test interview was performed to make sure that there was time enough to answer all the questions, since the goal was to go through with interviews within an hour. During the test interview it was possible to ensure that the questions was made in that way that they were understandable, and the answers as sought was covered and no important question was missing. There were no major changes made after a test interview and the review was made.

The interviews were planned in an early stage of the project to guarantee that all respondents would be able to participate. An e-mail was sent in advance to the respondents with information about the purpose of the study and the upcoming interview, aiming to prepare the respondents for the interview, see Appendix 2. Observations were made on site and photos were taken to complement the interviews and provide support in the analysing process. The interviews lasted between 30-60 minutes where one of the researchers played an active role, leading the interview, and the other had a passive role looking for opportunities for asking follow-up questions. The interviews were recorded, and additional notes were taken.

Table 4: List of semi-structured interview respondents.

Respondent	Actor	Role of employment	Date	Length
1	External expert	Partner/ Senior Business Analyst	2018-03-09	57 min
2	Dairy manufacturer	CEO	2018-03-12	45 min
3	Dairy manufacturer	Administration Manager	2018-03-12	22 min
4	External expert	Consultant, Blockchain evangelist	2018-03-13	67 min
5	External expert	CIO and Chief of Development	2018-03-13	43 min
6	Distribution company	Logistics and Transportation Manager & CEO	2018-03-13	45 min
7	Wholesaler	CEO	2018-03-15	39 min
8	Wholesaler	IT Manager	2018-03-15	57 min
9	External expert	Project Manager/ Business Analyst	2018-03-16	46 min
10	Retailer	Sales Manager Perishable Goods	2018-03-16	33 min
11	External expert	Senior Business Analyst	2018-03-22	38 min
12	External expert	CEO	2018-03-23	22 min
13	Retailer	Store Manager	2018-04-06	15 min
14	External expert	Project Manager	2018-04-23	22 min
15	External expert	Consultant	2018-04-27	43 min

Expert interviews

Because of the topic of the research being quite unknown and under development, the interviews opened up for a snowball effect, meaning that interviewees often recommended contacting people further with potentially more or complementing information than given by themselves. This opened up for some expert interviews along the process were the researchers took opportunity to talk to experts as it occurred to gain more insights. As more knowledge was gathered also more questions came up, hence expert interviews were conducted during the iterative process. The expert interviews were of unstructured interview characteristics (Gray 2017). The expert interview respondents differed from the semi-structured interview respondents and are not included in Table 4.

3.4. Data analysis

The data analysis was made continuously and iteratively through the whole research process. To support the systematic combining, concept mapping and data reduction of the transcribed empirical data was used in order to find and develop final findings and conclusion.

3.4.1. Transcribing

The data collected from the interviews was transcribed in favour to make it possible to analyze and gather an understanding of the case. The level of detailed transcription depends on the study. As the study does not go into social interactions, the transcriptions are simplified, only covering the answers of the interviews without taking tone, timing and pauses into account (Allen 2017). After the data collection the interviews were listened to several times by both researchers and summarized individually to collect important thoughts and issues and to find a red thread of opportunities and challenges.

3.4.2. Data reduction

The study is of the characteristic of mapping a supply chain where the important part of understanding the data was to catch the key concepts and practices. As for this study it meant to find how practices were done within the case study of traceability. Further, since the research questions include to develop an understanding of the possibilities and challenges of an implementation of a traceability system supported by blockchain in the specific case, the understanding of the data had to be carefully considered. Data reduction was used to select, focus and abstract key data from the interviews (Simons 2009).

3.4.3. Concept mapping

To analyze the data, the method of concept mapping was used. By organizing and gather the summarized interviews into different themes and categories conclusions could be made and linked with theory (Simons 2009). The mapping was done in a workshop where the data was focused into different themes to enable identification of these opportunities and challenges in the aim to answer the research questions. In the workshop the final summarizing of the interviews was done, comparing and adding the notes from passive researcher in the interviews, looking at the photos taken on site and listening to the interviews once more.

The final analysis, constituted by a final mapping of themes and gathering of results, was done in an additional workshop, coupling the empiric data to the research questions and the theoretical framework.

Results from the concept mapping was further applied to theory, through the iterative process, continuously matching theory with empirics to include more relevant theory, findings and conclusions to the study.

3.5. Ethical consideration

Ethical issues are not to be ignored and should be considered an important part of doing business research (Bryman et al. 2011). An ethical approach has been applied throughout the study in order to handle ethical issues like integrity and responsibility by showing respect toward the interviewees and honour the commitments about privacy. Bryman et al. (2011) lists four principles to take in consideration when doing business research; harm to participants, lack of informed consent, invasion of privacy, and whether deception is involved. To respect these ethical considerations different actions were taken. The respondents were informed about the purpose of the study and permission to tape record the interviews were given at the beginning of every interview. The summarizations were sent to the respondents respectively for them to confirm the interpretations and transcription. However, in order to conduct a moral and ethical research, the respondents could only correct data in case of mishearing's or misunderstandings. Respect was taken to the participants wishes to not take part in the study. Further, the respondents are anonymous in the report and the individual answers are expressed as the opinion of a specific actor or as an external source. A final copy of the study was sent to the respondents.

3.6. Trustworthiness

To assess the trustworthiness of the qualitative research done, the study was evaluated according to the four criteria presented by Lincoln and Guba (1985). The criteria are; *credibility*, *transferability*, *dependability* and *confirmability*. Credibility was accounted for by the use of triangulation to enforce the "truth" of the findings through the utilization of multiple perspectives. This approach includes methodology triangulation, multiple data source triangulation and theoretical triangulation. The credibility could have been improved by considering a wider delimitation to the case study, involving more actors that operates in the case study supply chain. The transferability of the study is considered relatively high even though the contextual significance of the qualitative research. The generalizability in the framework was considered to be applicable for different types of supply chains. Increased transferability can be reached by a thick description or describing the phenomenon or context in sufficient detail. The dependability was strengthened with an inquiry audit to examine both the process and the product of the study. The last criteria are characterized by the level of neutrality and objectivity of the research and validated by and audit trail (Lincoln & Guba 1985). Worth to notice is that research based on qualitative data gives less opportunity for generalization than quantitative research, also a single case study always limits the generalizability of the study.

4. The current supply chain

This chapter aims to answer RQ1 and will present the setup of the case supply chain of a dairy product. The setup includes the physical flow, informational flow, the device and software setups and certifications and standards used by the members.

4.1. The physical flow of the milk in the case supply chain

The physical flow of the dairy supply chain is visualized in Figure 6 and described in detail in this following section.

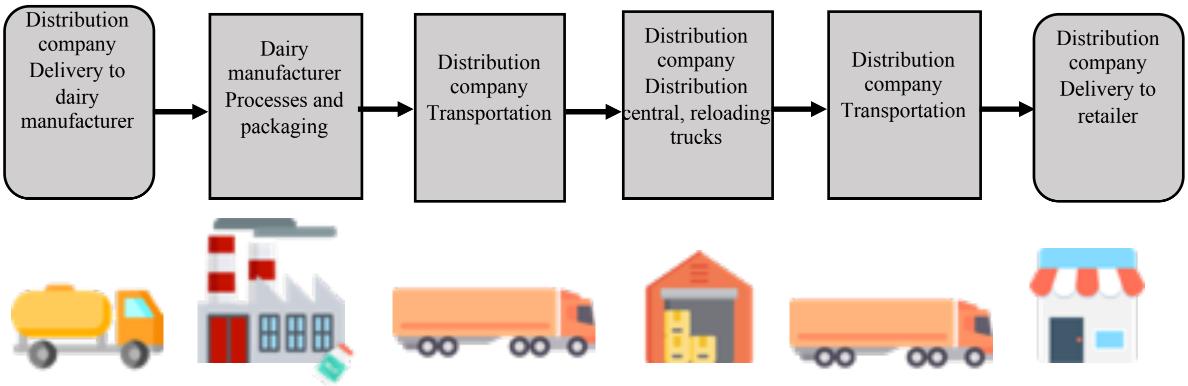

Figure 6: The case supply chain.

The scope of the case study has its starting point once a batch of milk has been received at a dairy manufacturer. At the delivery of milk in the morning, it is being pumped from the milk transport tanks to silos at the dairy. The silos can contain up to three days of delivery mixed from up to 15 different farmers, meaning that the production processes can start either the same day as delivery or up to two days after delivery. Because of the time between delivery and production processes can differ up to three days, resulting in five different scenarios of when in time actions are taking place in the supply chain. The different time windows are shown in Table 5.

Upon delivery, a manual temperature check-up is done, a delivery note is handed over together with samples of different milk batches for further transportation to an analyse centre. The milk samples will be delivered at analysis centre within 30 hours after the pick-up at the farm, meaning that the tests will be analysed for different food safety parameters in the middle of the next coming day after pickup.

The milk is processed and monitored in the dairy manufacturer before it reaches a packaging area. During the packaging stage, milk cartons are tagged with the date of production, best-before date and a manufacturing ID number using a laser-tag. The cartons are produced and marked with a barcode by an external supplier to the dairy. Once packed, the milk cartons are stacked on trolleys and placed in a cold storage waiting for being picked up. The trolleys are picked up by the distribution company every day in the afternoon and transported to their distribution centre where the milk first is reloaded to different areas and then loaded on to delivery trucks according to different driving routes. The milk is stored in the distribution centres cold storage during one night before last transportation to the retailer. When the milk arrives to the retailer the truck driver is loading the trolleys straight into the cold storage where the retailer personnel later is loading the cartons into the fridges. Customers picks the milk from the fridges, pays the milk in the cash register and brings it home with them.

Table 5: The different scenarios for when supply chain actions happen in time.

	Dairy manufactory		**Distribution company**			**Retailer**
Action	Processing	Storage	Transportation 1	Storage	Transportation 2	Storage
Scenario 1	Day 1 afternoon	Day 1 afternoon	Day 2 morning	Day 2	Day 3 morning	Day 3
Scenario 2	Day 2 morning	Day 2 morning	Day 2 afternoon	Day 2	Day 3 morning	Day 3
Scenario 3	Day 2 afternoon	Day 2 afternoon	Day 3 morning	Day 3	Day 4 morning	Day 4
Scenario 4	Day 3 morning	Day 3 morning	Day 3 afternoon	Day 3	Day 4 morning	Day 4
Scenario 5	Day 3 afternoon	Day 3 afternoon	Day 4 morning	Day 4	Day 5 morning	Day 5

Table 6 shows the cost and the CO_2- footprint per produced litre of milk for different actions made in the investigated part of the dairy supply chain. The storage costs are assumed to be included in the processing cost and transportation cost respectively.

Table 6: Costs and CO_2-footprint for actions made within the limitation of the investigated supply chain (Nilsson & Lindberg 2011; Ektander & Jonsson 2015; Coop 2015; Falköpings Kyltransporter AB 2018).

	Dairy manufacturer		Distribution company			Retailer
Action	Processing	Storage	Transportation	Storage	Transportation	Storage
CO_2 footprint [g CO_2-eqv. /l]	19,97	0,03	10,4	0,06	0,717	0,1
Cost [SEK/l]	3,56		1	-	0,5	0,88

From the interviews, three layers of IoT are identified which digitalizes the physical supply chain of milk. All the actors along the supply chain currently have access to and use a hardware, a Supportive Administration Software and a Master of Administration Software. The hardware is used to capture data from the physical flow, the supportive software is used within hardware's to handle and transform the data for further transfer to the Master of Administration where the data is stored and managed. Each member of the supply chain has its own closed system with small portions of data exchange between members. Figure 16 shows how the three layers are connected, visualized in the grey areas.

4.2. The dairy manufacturer

Following section presents the dairy manufactures information flow of order and production planning, their actions for food safety, preventing food waste and software and hardware used to support those processes.

4.2.1. Software setup

The dairy manufacturer has a setup of different software managing their information flow in their everyday business, see Figure 7. For the business operations planning, two main software's are used; Excel and Visma. Excel is used for production planning and Visma is used for order management, invoices and the economic administration.

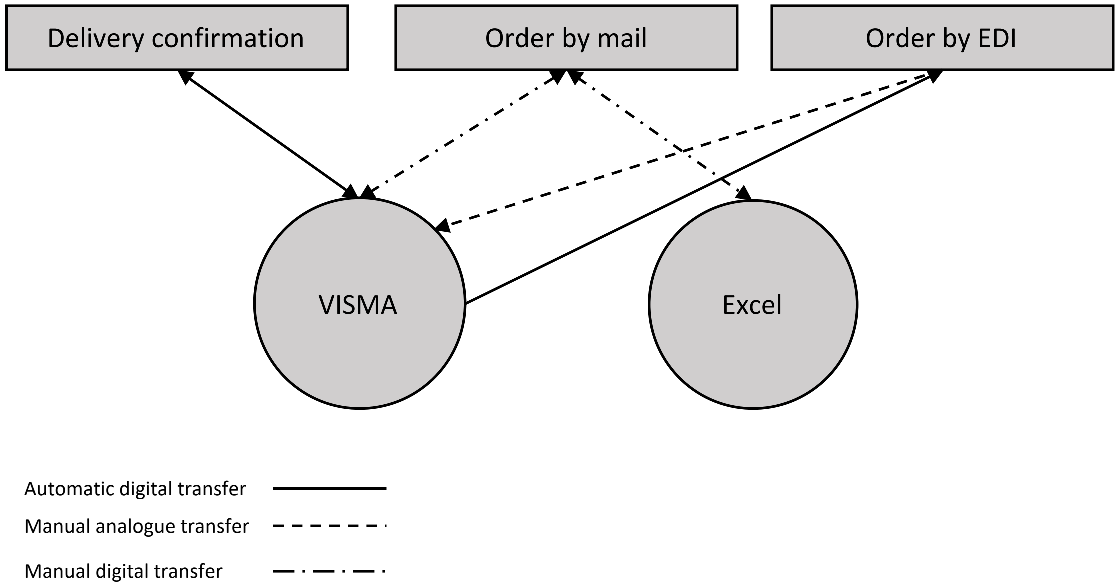

Figure 7: The software setup for business operation planning at the manufacturing company.

4.2.2. Information flow

The information flow is separated into delivery information and production planning as shown in Figure 8 below. Most of the incoming orders are delivered by EDI, the rest are delivered by mail or phone. The first step in order to trigger production is to manually convert the incoming order into Visma. The EDI-orders are digitally transferred and the manually sent orders also has to be manually administrated. All the Excel data has to be manually added into the spreadsheets. The data that is inserted into Excel is data about orders, taken from Visma, and manually collected data about the delivered milk, taken from the delivery notes from the truck driver. The delivery note is a paper document that has to be transferred into Excel for further administration.

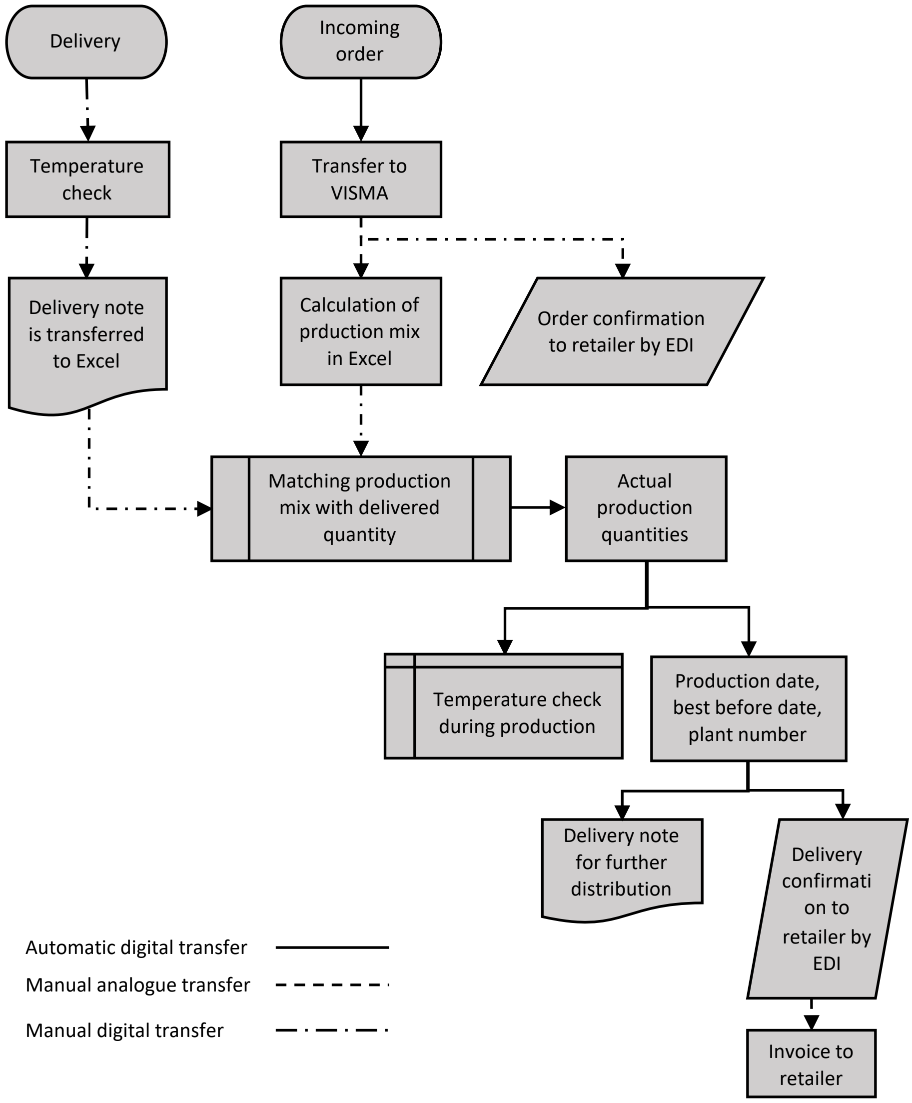

Figure 8: The information flow of incoming data and incoming orders to the manufacturer.

4.2.3. Food safety

The dairy manufacturer is practicing the HACCP standard and are certified with IP Livsmedel. The dairy manufacturer also has a part of its production certified with KRAV. The third-party certifiers, Livsmedelsverket and Säffle municipality, audits that laws and regulations regarding environment and health on the workplace are being followed. The dairy manufacturer is working with the case study wholesaler organization which also make their own audits to assure that their producers are following their specific code of conduct.

Respondent 2 says that "to trace what products that has to be recalled, the personnel at the dairy manufactory have to manually look into their software systems for delivery notes where you can see what retail stores got delivery from a specific production date as well as what quantities they've got".

The dairy manufacturer uses a web-based software to register all the required information for certifications and regulations. The data is entered manually into the software. The setup for administration of certifications is seen in Figure 9.

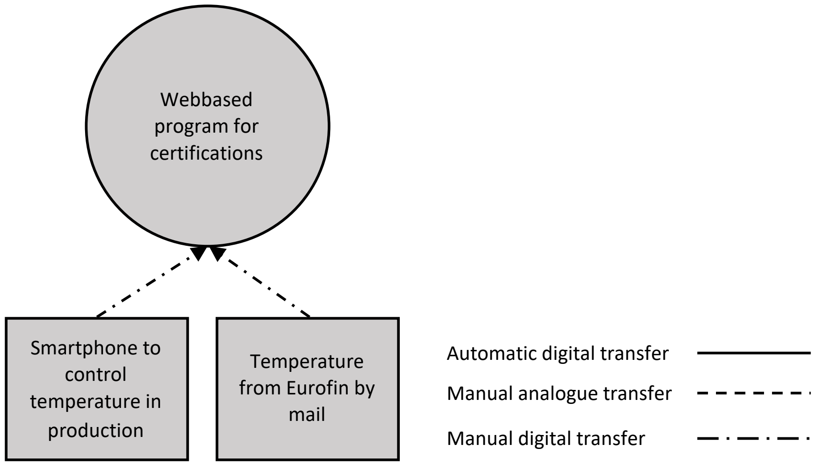

Figure 9: The administration of certifications.

4.2.4. Food waste

When the demand is not met by the supply, and more milk is delivered to the dairy manufacturer than the demand responds to, the surplus is sent to further be refined to desiccated milk as an act to prevent food waste. In case of a product recall the dairy takes back all the milk, which either is sent for digestion or disposal depending on the cause.

4.3. The distribution company

Following section presents the distribution company's information flow for order and production planning, their actions for addressing food safety, preventing food waste and software and hardware used to support these processes. The distribution company include delivery trucks and a distribution centre.

4.3.1. Software setup

The distribution company setup of devices and software for daily administration and logistics planning regarding the dairy manufacturer outlines by Visma and a mail account for manual logistics planning, see Figure 10.

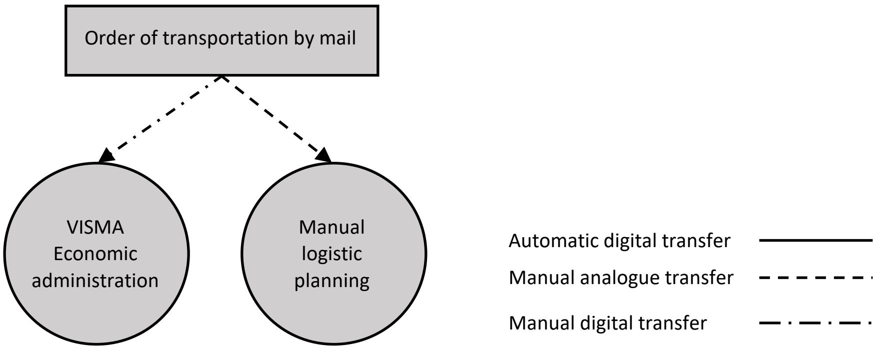

Figure 10: The administration setup for orders at the distribution company.

4.3.2. Information flow

The distribution company delivers milk from different farmers to the dairy manufacturer two times a day. The truck driver hands over a physical delivery note including information about temperature, farmers, volumes and timestamps that is printed out in the delivery truck. The request for distribution services from the dairy manufacturer to the retailer is sent by mail and further handled by manually insert the request into Visma. The request is printed out on paper and the logistic planning is made manually with the support of the printed requests. The process is shown in Figure 11. The distribution company have, upon demand from other customers, invested in smartphones for managing the distribution of their products. The smartphones are not used for managing the distribution of the case study products.

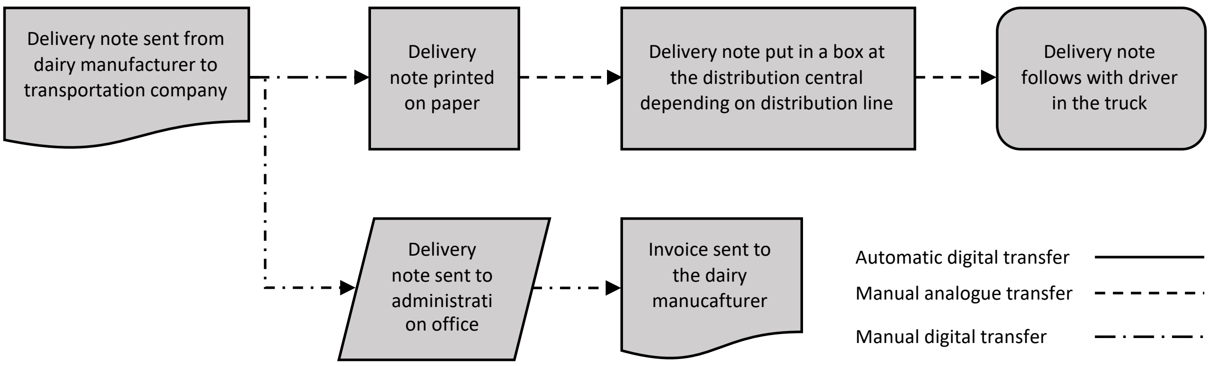

Figure 11: The handling of a request for transportation services.

4.3.3. Food safety

Besides the distribution planning and economic administration, the distribution company also controls the cold chain in their part of the FSC. The trucks are provided with real-time temperature sensors connected to a display and printer inside the truck. A truck service company is used to provide complete documentation of temperature data from the trucks needed for their certifications, this complete data is sent as a computer-file to the distribution company when a truck is on service check.

The distribution centre is a cold warehouse equipped with temperature sensors and displays which provides real-time data of the temperatures. Temperature data is printed every five minute and accessible when wanted. In case of deviant temperatures an alarm is sent to three different authorities.

The distribution company are certified with ISO 9001 and ISO 14001 regarding the handling of food as well as certified according to the regulations of Swedish Transportation Agency with ISO 39001 regarding their transportation services.

4.3.4. Food waste

The distribution company estimates their food waste regarding the milk to be nearly zero. The milk that is wasted is often due to transportation damages.

4.4. The retailer and wholesaler

Following section presents the retailer and wholesaler's flow of order and production planning, their actions for food safety, preventing food waste and software and hardware used to support those processes.

4.4.1. Software setup

The wholesaler manages the Master of Administration Software which is an ERP called Movex/M3. From that system several supporting systems are connected in order to plan and manage logistics and sales at the retailer, see Figure 14. Relex is connected to Movex/M3 creating automatic orders based on historical data and given the levels of maximum and minimum balances. WebMethods, connected to a FTP server, is used to connect suppliers and enable EDI orders. Denso and BIRK are the software used in hand-terminals at the retailer and Conille POS is the software used in the cash registers, these are also connected to Movex/M3. OEBAS is managing the self-monitoring and the only software not connected to Movex/M3, why it is also not linked to the master software in Figure 12.

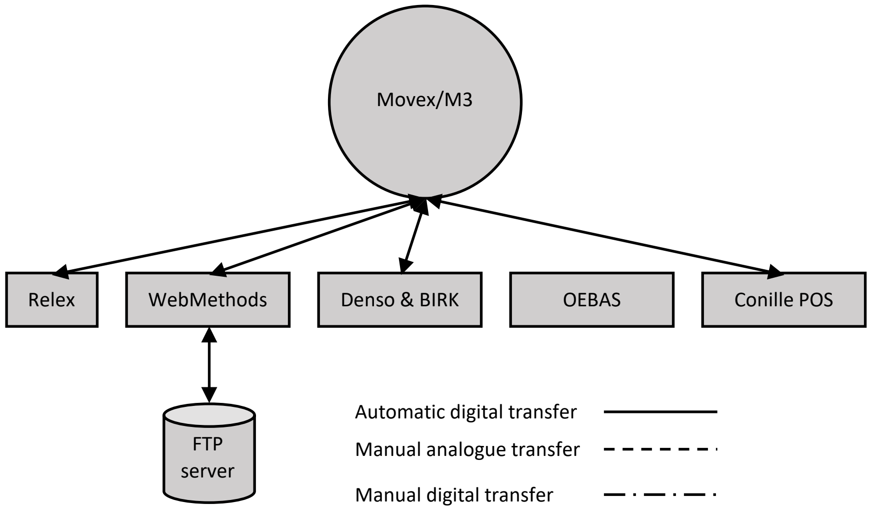

Figure 12: The software setup for the information flow at the retailer.

4.4.2. Information flow

The information flow of an order, as seen in Figure 13, at the wholesaler and the retailer can use all the software's described in the previous section.

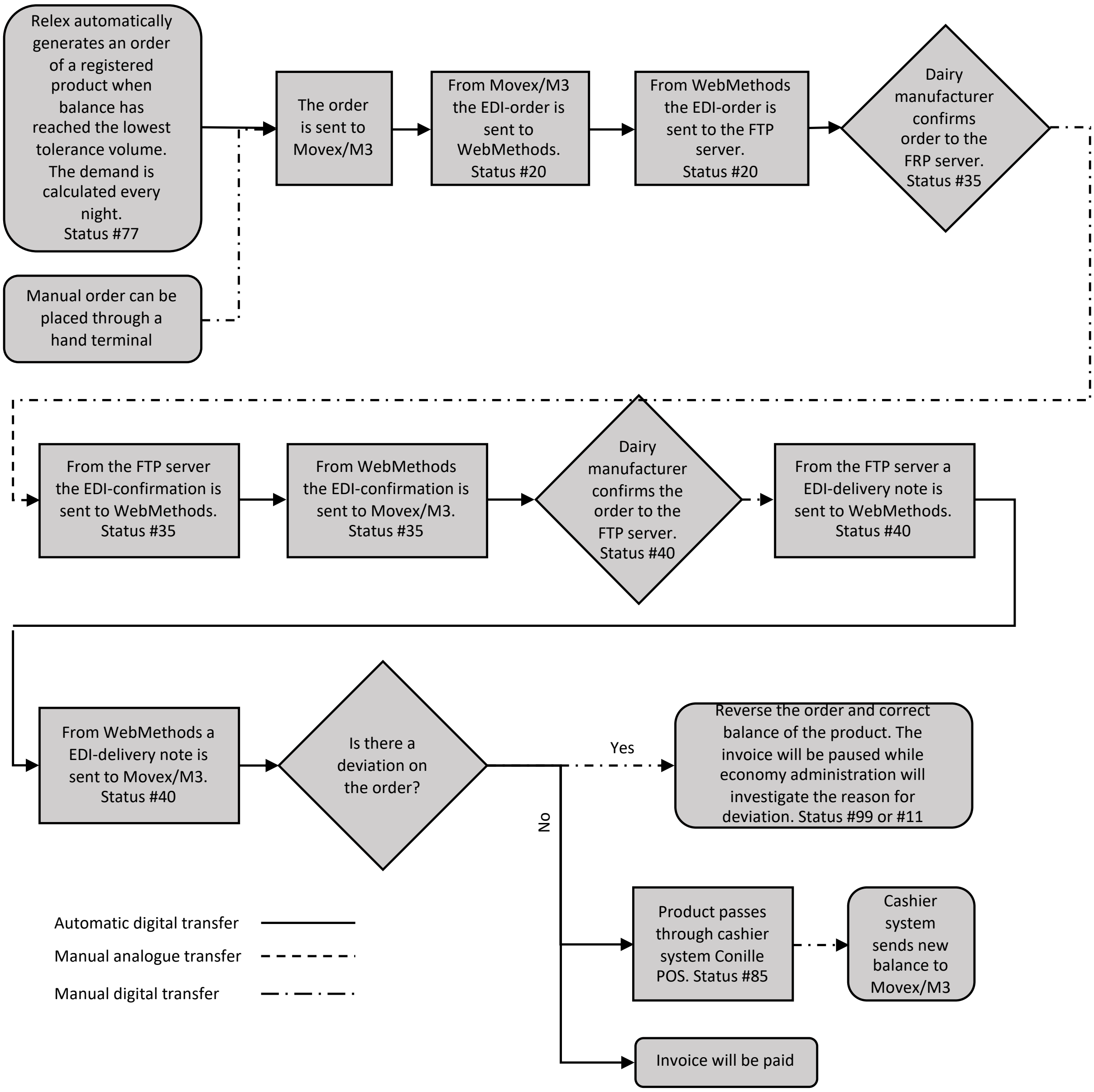

Figure 13: The information flow of incoming orders at the retailer.

4.4.3. Food safety

At the retailers, the refrigerators are equipped with sensors, measuring the temperature every 20 minutes. If the measured temperature would fall outside the predefined accepted interval an alarm is sent to different authorities. Depending on how long the temperature has been outside the accepted interval, the food will be wasted or cleared for selling.

The retailer is certified with different ISO standards and follows the laws and regulations set by Swedish Food Agency and the different municipalities in Värmland County depending on store location. For self-monitoring of the food safety the retailer is working under the principle of HACCP, in addition the personnel do temperature checks with a laser thermometer on dairy products twice a week simultaneously with the deliveries. The temperature data is manually documented in OEBAS. If the store staff suspects the milk not being at the right temperature, an extra control will be made.

4.4.4. Food waste

One of the strategies used by the retailer to prevent food waste is to refine food in their restaurant or deli counter. Another strategy is to manually discount products that are close to expiration date. The discount is increased the closer to the expiration date it becomes. Other initiatives discovered from the interviews are to offer products that has just gone out of best before date, but still has a legitimate expiration date, to the personnel. It was also shown that there is a continuous work with digitalization of the ordering process.

5. Implementing a blockchain framework

The following chapter aims to answer RQ2 and will present a possible set up for a framework including blockchain technology. The different blocks and the interaction between different layers in the framework will be described and visualised.

5.1. The framework

The following section provides a possible framework for an integration of blockchain into the case study supply chain. The framework is based on the empirical findings together with findings from the theory.

As explained in chapter 2.4.1, each actor registers themselves on the network with their private key and uses the public key for authorization and identification (Kairos future 2017). The data entry can be done either manually or automatically by the actors in the network or supply chain by authorizing themselves with their private key on hardware devices connected to a software application providing an interface for the new data. The blockchain can be of different characteristics; public or private. Depending on the choice of blockchain, the level of security will be affected. A private blockchain is believed to be less secure than a public due to the risks of alliances. Though, the private blockchain provides the ability to choose which actors that should have a certain insight and be able to affect the chain. To connect and enable a more extent data sharing along the DSC two new layers are proposed in addition to the existing three layers, all layers are shown in Figure 14.

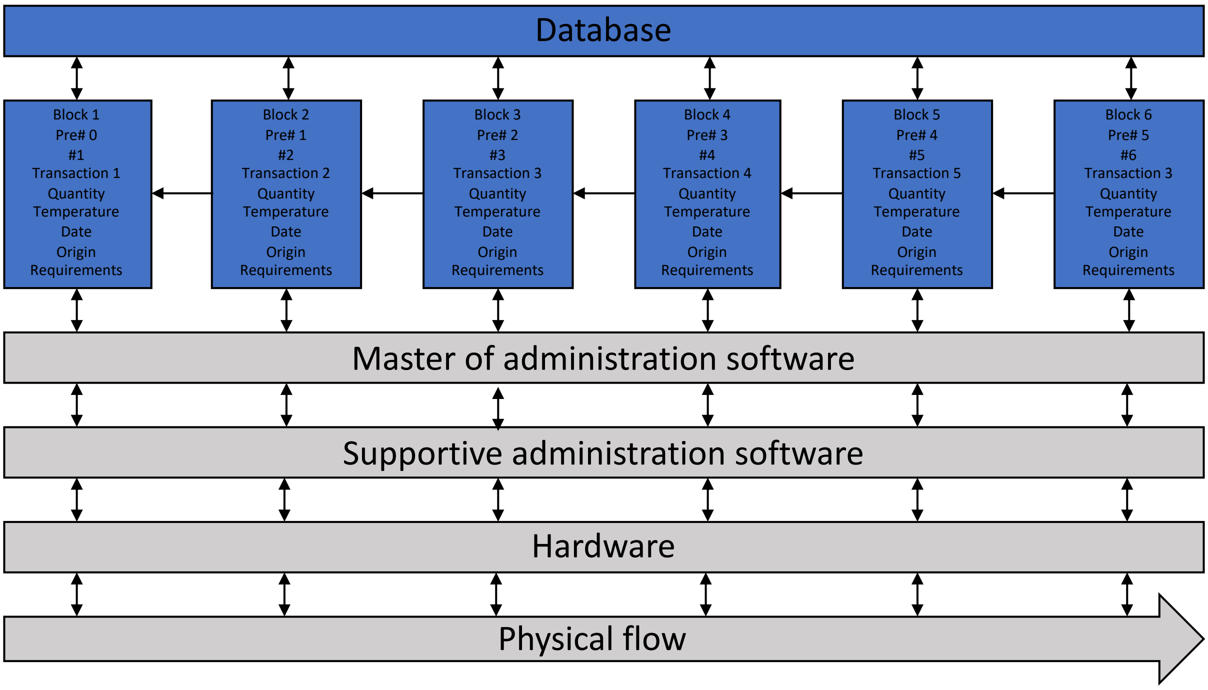

Figure 14: The proposed framework of a blockchain supported traceability system.

The framework proposes a layer of blockchain which is connected to all of the FSC members Master of Administration software. The new layers on top of the existing layers collects, connects and manages relevant product information through the supply chain. Each product would essentially be provided with a unique digital summary that is updated along the supply chain containing all relevant information gathered trough the supply chain. The blockchain will further be connected to a global database, available to all members in the supply chain. Table 9 in Appendix 1 provides an extended summary of current technology being used in the FSC and examples of technology that can be utilized in the proposed framework. "A public open blockchain is the most secure type, hence there is no single point of failure" (Respondent 4), which is one of the arguments to suggest a blockchain framework that is public, regarding the confirmation of transactions, would fit the case study supply chain since it is found to be the most secure according to theory and the layer of database is distributed which offers secure backups with a permissioned access for the confirmations and access of data.

Why the blockchain is considered to be highly rated for providing secure data transactions is due to the consensus processes. This research presents three types of consensus, proof of work, proof of stake and byzantine fault protocol. They all have in common to confirm transactions in a distributed environment, with distributed protocols of transactions stored in a secure and encrypted way.

However, this research does not provide any recommendations of which consensus protocol to use, since it would require an even deeper understanding of the processes.

The blocks are proposed to be connected to a logic such as smart contracts, whereby the framework will demand block-specific requirements for different parts of the supply chain. Figure 15 shows the process flow of a smart contract applied on the case study context. Each block is connected to a smart contract with requirements that has to be fulfilled in favour to complete a block and trigger the creation of next block in the chain. Table 7 shows when a block is created and what new data as well as what data from previous blocks that is required for the creation of a new block and validation of a transaction.

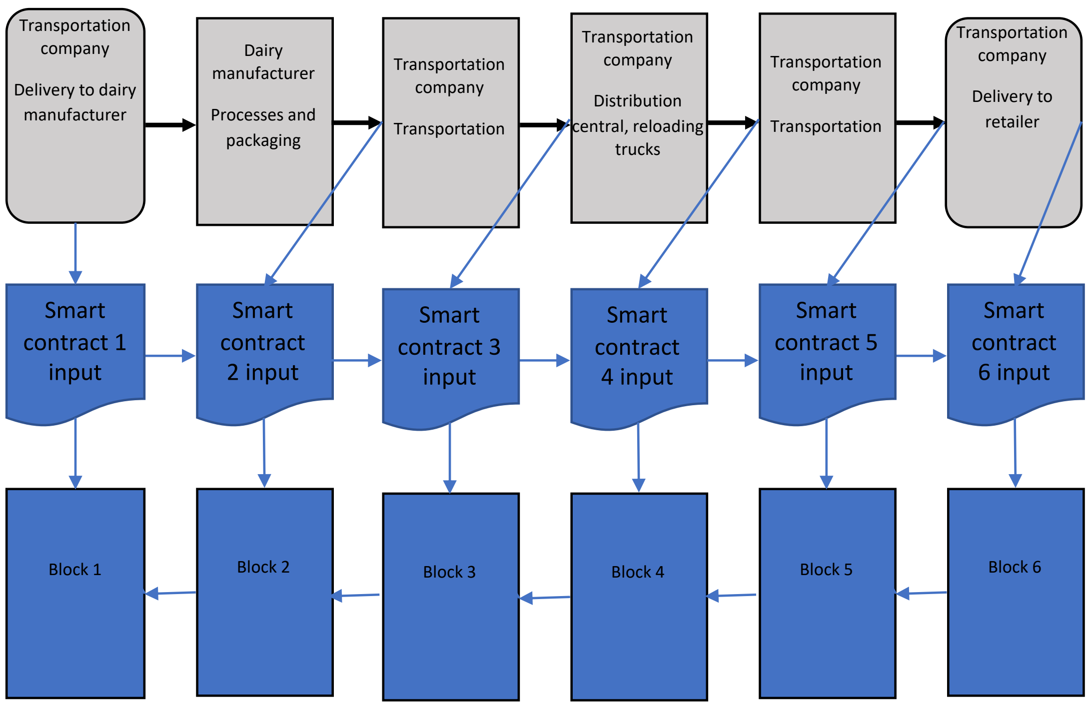

Figure 15: The proposed process of interaction with smart contracts on the blockchain.

The empirical and theoretical findings declare that temperature, volume, timestamps, supply chain actor signatures, order number and batch number are required variables that should be available and recorded in the framework (Bosona & Gebresenbet 2013; Pizzuti & Mirabelli 2015; Aung & Chang 2013; Wognum et al. 2010). Most of this information, except from temperature data, is in one way or another declared somewhere in the supply chain but the statement about the importance of temperature can be is strengthened to be a key variable to track from the study done by Pei et al. (2011). To prevent food waste, ensure food safety, and increase traceability it is found in the literature that smart contracts could be a well-suited solution (Abeyratne & Monfared 2016).

Table 7: The proposed smart contract requirements.

Block nr.	Created	Smart contract triggers	
		New input	Input from previous block
Block 1	When the milk is delivered to the dairy manufacturer	Temperature 1 Volume Time & date Farmer ID	-
Block 2	When milk is picked up by distribution company	Temperature 2 Retailer order	Volume Time & date
Block 3	When loaded into distribution centre	Temperature 3 Logistics order	Retailer order Time & date
Block 4	When transferred from distribution centre to delivery truck	Temperature 4	Retail order Logistics order Time & Date
Block 5	When loaded to the retailer fridges	Temperature 5	Retail order Logistics order Time & Date
Block 6	When picked up by the consumer	Temperature 6	Retail order Logistics order Time & Date

5.2. Implementation discussion

As the empirical findings confirms, there is a lack of motivation to improve collaboration among the stakeholders of the supply chain investigated (Bosona & Gebresenbet 2013; Stranieri et al. 2015; Trienekens et al. 2012). The barriers that are identified for an implementation of blockchain are high costs, lack of knowledge of the value creations (Kaloxylos et al. 2013), lack of knowledge of IoT (Haddud et al. 2017). The technology of blockchain is still immature and need to be developed and standardized (Lu & Xu 2017; Tian 2017). In order to find value creations, there is a need of IoT investments in order to set the foundations of an effectively working traceability system (Saberi 2018). As the respondents are having a hard time seeing the value of an investment; "It's all about money; money, money, money" (Respondent 10), the theoretical findings confirm that there is an uncertainty if the improvement is greater than the investment (Abeyratne & Monfared 2016). Further, IoT constitutes of a complexity in data that has to be managed with smart applications for optimizing the data (Tzounis et al. 2017). It is believed that in the future, there has to be common structures for the whole FSC where information is saved along the supply chain, from the producer to the consumer. It is expressed that "…the winner is the one who manage to get all onboard on the train, but that requires some sort of standardization" (Respondent 12).

An overall trend in the interviews is the perception that the initiator, to create and implement a blockchain traceability framework, has to be a member of the supply chain with a lot of resources. It is discussed whether that member is the wholesaler/retailer or the producer. Most of the respondents believes that it should be the manufacturers responsibility even though some argued that the actor closest to the consumer, thus the retailer, would be the one with the most incentives due to the possibility to provide additional value-adding services. The conclusion in our case context, based on the empirical findings, indicates on the manufacturer to be the initiator even though the wholesaler is the member of this supply chain with greater power and resources.

The empirical findings furthermore reveal that the manufacturer is having a hard time seeing the motivators of doing such a radical initiative since and only do what's necessary; respondent 2 says "I know what requirements that's out there […] further is no idea to go […] the retail managers said that "*we don't care if you can trace on molecular level, if there's a problem we throw everything out*"[…] I talk to the retailers still, but they say they still don't care". The manufacturer is a small manufacturer who does not have the ability to influent radical measures that onto the whole supply chain. Still, they are making some extra efforts since they offer a KRAV labelled product that requires extra work and regulations. This contradiction could be supported by Stranieri et al. (2017) meaning that making changes that provides customer value, such as a label, provides a higher motivator than only making changes of higher traceability between business members in the supply chain. Therefore, the difficulty of seeing a value of a high-level traceability system among actors needs to be met in order to motivate an implementation. Although Chen et al. (2013) implicates that several benefits can be obtained if an actor of greater power, such as the wholesaler, encourages suppliers to find other ways of collaborating in order to reach better traceability, instead the case supply chain actors are experiencing resistance from the wholesaler resulting in an opinion that technologies like the blockchain technology would never work in practice. As earlier referred to, the method of signalling seems to be used ineffectively in this case, as an effect of information asymmetry (Kaloxylos et al. 2013). Neither does the distribution company feel any motivation to take initiative for improving their traceability management unless they are being pushed by their customers. Moreover, European commission (2016) implicates that European countries have a high level of traceability within their business processes, supporting the empirical findings of questioning the actual need of an improved traceability system.

6. Challenges and possibilities

This chapter aims to answer RQ3 where a discussion is held for the challenges and possibilities an implementation entails, both in the context of the studied FSC as well as in general. The chapter also includes the potential cost and environmental savings for a litre of milk in case of a product recall with an implementation of a blockchain supported framework. This chapter has the same structure as the theory chapter in order to link the theory to the empirical findings.

6.1. Traceability

The blockchain framework provides the possibility to track and trace all the way from the dairy manufacturer to the retailer. The proposed framework requires some investments in hardware and software, but these are considered relatively low and justified as the market prices of IoT devices are constantly decreasing (Mattila et al. 2016). "…the implementation of a traceability system goes fast, but it requires the table to be set for the meal" (Respondent 1). However, there is a lack in the current supply chain of connecting the physical batch to the digital batch-number used in the information flow, to solve this connection the milk packages have to be labelled with batch numbers and added to the data collection in every supply chain transaction. Moreover, this problem is not only occurring in this study, but is the same problem in the salmonella scandal in 2018 (Willsher 2018), why it is an issue that has to be solved.

6.1.1. Transparency

By using blockchain technology to support a traceability system it provides the possibilities of a high level of transparency in a private and more secure way (Pant et al. 2015). The level of transparency is decided by the supply chain members willingness to share information and data. There are split opinions on what data to share within and outside the FSC. One respondent describes it as follows:

> "There have been discussions about sharing selling volumes with suppliers earlier […] but the value creation wasn't met, why the information sharing was never made […] The challenges lies in changing business models […] it is not ok to share information vertically among supply chains to competitors". (Respondent 8)

However, respondent 10 says that "I have no secrets in my computer, sales numbers and such are no secret, but that's a decision that the wholesaler have to take". The empirical findings indicate that there is a resistance from the case stakeholders of complete openness of data due to the fear of competitors taking advantages of insight to their business, why a permissioned managing of the framework is proposed to the case study. Moreover, Mattila et al. (2016) shows in their study that openness leads to completive advantages.

6.1.2. Food safety

To optimize the processes in a supply chain the traceability system can be used to find CTP's (Karlsen & Olsen 2011). Some CTP's were found in the study, e.g. there is little documentation made within the distribution central and there is confusion between the members of missing pallets. Until today, there has not been any major scandals, but if there would be it is crucial to have total control of all milk packages (EC 2007), and this is a CTP that would be failing. A blockchain implementation could not only solve the problem of an efficient traceability solution but also the need for saving backup documentation in a secure way (Svensk mjölk 2007; Sarkis et al. 2011; Sayogo et al. 2015).

It appears from the empirical study that it can take about half a day to trace the source of and block products affected in case of a product recall, compared with a few minutes by the support of blockchain (Bajpai 2018). The routine to communicate a product recall differs depending on where in the supply chain the alarm occurs but the information is communicated via phone calls or e-mail. The communication strategy is of importance to reduce human hazards and could be streamlined by enabling faster communications and accessible digital information for all actors. As the blockchain provides a more collaborative approach along the supply chain it makes it possible for a more solid product recall system, the possibility of a pre-warning system as suggested by Wang and Yue (2017) and the possibility to work with other values such as CTP (Karlsen & Olsen 2011) in the aim to trim processes and finding a more secure and efficient supply chain. From analysing the data, based on the findings of blockchain to provide immediate information about a product recall instead of half a day's delay, it was found that savings could be made both in costs and in environmental emissions expressed in CO_2-footprint. Table 8 illustrates the current time window scenarios and a possible time window with a blockchain supported framework for traceability. The red colour represents when a product recall is received from the analysing centre that analyzes the milk from the farmers. The green colour represents when action has been made to stop the distribution of the milk in the supply chain and the chain can be considered as safe.

Table 8: Different scenarios for noticing and addressing a potential product recall.

	Dairy manufactory		Distribution company			Retailer
Action	Processing	Storage	Transportation	Storage	Transportation	Storage
Scenario 1	Day 1 afternoon	Day 1 afternoon	Day 2 morning	Day 2	Day 3 morning	Day 3
Scenario 1 blockchain	Day 1 afternoon	Day 1 afternoon	Day 2 morning	Day 2	Day 3 morning	Day 3
Scenario 2	Day 2 morning	Day 2 morning	Day 2 afternoon	Day 2	Day 3 morning	Day 3
Scenario 2 blockchain	Day 2 morning	Day 2 morning	Day 2 afternoon	Day 2	Day 3 morning	Day 3
Scenario 3	Day 2 afternoon	Day 2 afternoon	Day 3 morning	Day 3	Day 4 morning	Day 4
Scenario 3 blockchain	Day 2 afternoon	Day 2 afternoon	Day 3 morning	Day 3	Day 4 morning	Day 4
Scenario 4	Day 3 morning	Day 3 morning	Day 3 afternoon	Day 3	Day 4 morning	Day 4
Scenario 5	Day 3 afternoon	Day 3 afternoon	Day 4 morning	Day 4	Day 5 morning	Day 5

The potential savings in case of a product recall with a blockchain framework for traceability are shown in Figure 16 and Figure 17, representing costs and CO_2-footprint respectively.

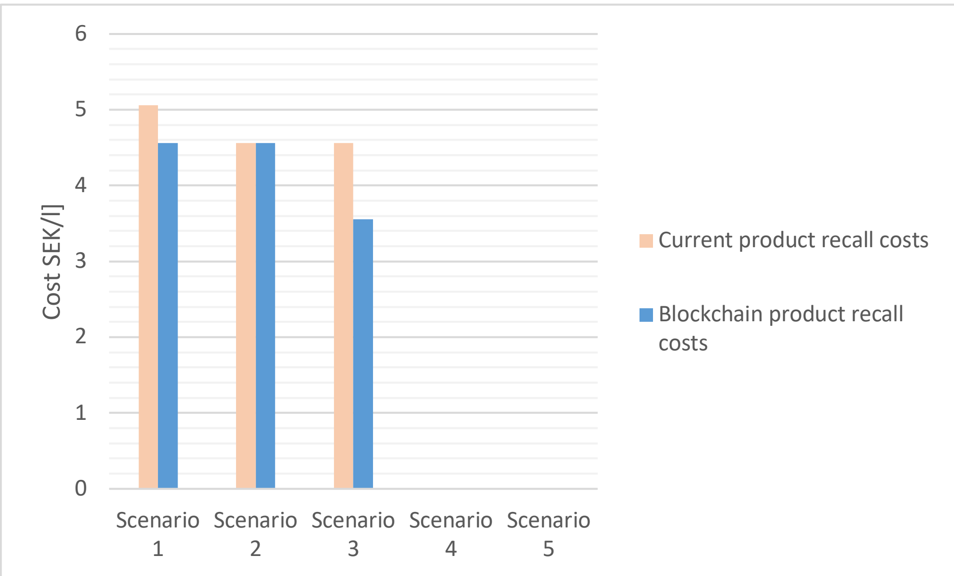

Figure 16: Estimations on the difference in costs in the different scenario with and without a blockchain supported framework introduced.

The diagram in Figure 16 indicates that monetary savings can be achieved in scenario 1 and 3. The potential cost savings can amount to 0,5 SEK/l in scenario 1 and 1 SEK/l in scenario 3.

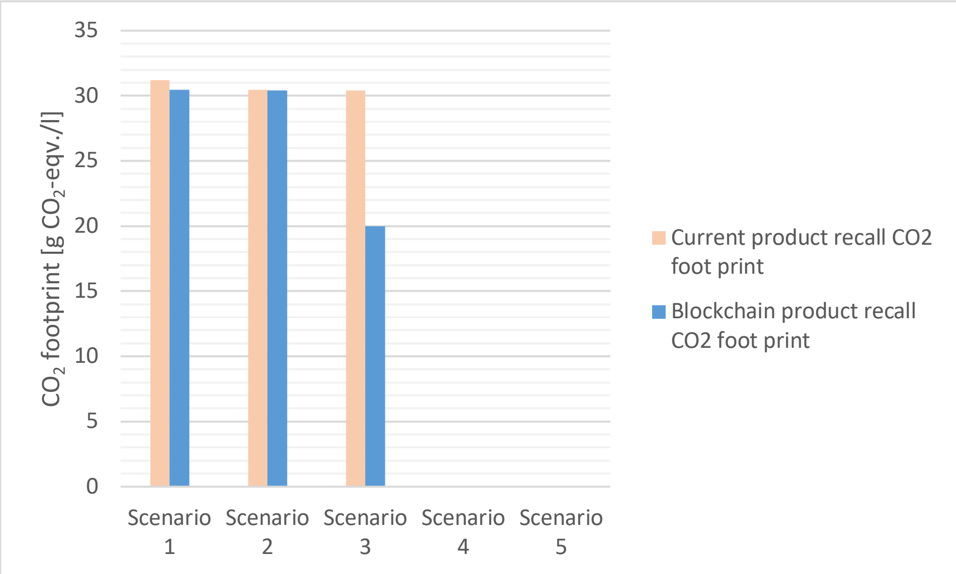

Figure 17: Estimations on the difference in CO2-footprint in the different scenario with and without a blockchain supported framework introduced.

The diagram in Figure 17 shows that environmental savings can be reached in scenario 1, 2 and 3. Savings in environmental emissions can sum up to 0,72 g CO_2-eqv./l in scenario 1, 0,06 g CO_2-eqv./l in scenario 2 and 10,43 g CO_2-eqv./l in scenario 3. Because the storage costs being included in the processing cost at the manufactory and in the transportation costs for the distribution company (see Table 6), scenario 2 shows no cost saving since the only difference is the storage time at the distribution centre. There are no savings in scenario 4 and 5 since the processing has not yet started by the time the test results are received from the analyzing centre.

6.1.3. Food waste

The digitalization is crucial to deal with human-made overestimations of the order quantity and hence buying too many entities leading to food waste and large costs, as respondent 10 implicates "It's all about try to meet the demand as close as possible, to be as close to break-even as possible".

According to empirical findings a prerequisite to create traceability and minimize food waste is to have an IoT-based production system implemented in the production, as recommended by EU (EC 178/2002). Respondent 5 talks about smart sensors which can ensure the cold chain and that the consumer should be able to access the data in an easy way.

> "…the reason that the retailers have to have a shorter expiration dates than what is actually needed is because they cannot guarantee the supply chain, but if we can deliver a product that can guarantee exactly what the products has gone through in the supply chain, they can prolong the expiration date which will have a huge impact on the food waste". (Respondent 5)

If there is an effective traceability system implemented and shared in the supply chain, the chances of detecting a deviation in product quality increases, hence reducing the risk of food waste further down the supply chain as achieved by Lyles et al. (2008), through a shared and more extensive documentation of standards and procedures.

The interviews reveal that the food waste reduction management is carried out differently depending on if it is in the manufacturing or the retailing stage. As for waste occurring at the manufacturer, the main objective is to trim the processes in the production in order to achieve higher levels of efficiency. Further, respondent 1 states that "in the end of the day it is about providing products that corresponds to the expected quality with a best before date that lasts long enough". The producers are often using three different dates that is followed with a product; day of production, best before date and the last date for sending the product further in the supply chain. As found in the theory and suggested in the framework, a smart contract can be implemented to keep control of these dates (Juri et al. 2016). The different dates can be used for tracking and preventing food waste at different stages in the supply chain. The last date for sending a product further has the purpose of keeping a required quality of the product and can be used for appropriate allocation depending on different tolerance levels at the end customer. Though, the interviews revealed that the industry have low insight in the consumers tolerance level that varies in different contexts. With the correct knowledge of the tolerance levels it would be possible to develop smart solutions to allocate different products with different quality and best before date to different consumers with varying tolerance levels. A solution based on this knowledge could possibly minimize food waste, as already being practised in small scale at the wholesaler. A collaborative FSC is shown to minimize food waste (Zhong et al. 2016; Radzyminska et al. 2016), needing only small changes to obtain great effects on sustainability and decreased food waste (Tostivint et al. 2017; Franke et al. 2013).

6.2. Trust

It is established by the empirical and the theoretical findings that a collaborative approach would bring several benefits towards a more solid and efficient traceability system (Mol 2015; Narsimhalu et al. 2015; Wognum et al. 2010). Although, it is necessary to provide a service that ensures the supply chain members privacy (Trienekens et al. 2012; Boyd et al. 2007), something that the blockchain technology can solve (Khan & Salah 2018; Nationalencyklopedin 2017). The empirical findings indicate that there is a willingness of sharing more information vertically in the supply chain, but a challenge is to agree on what information to share and to whom. Also, there is a resistance against sharing information to competitors. This is, according to Respondent 5, a big hindrance for the implementation of blockchain in a supply chain. Sarkis et al. (2011) and Sayogo et al. (2015) recalls that an information asymmetry is created by organizations with a lot of power within a supply chain, holding a lot of information to themselves.

The blockchain is designed in a way to create trust in a system without trust, why the need of third party organizations to validate transactions disappears (Abeyratne & Monfared 2016).

A concern that has been brought up by several respondents is the uncertainties regarding the human aspects of data entering. There will always be a risk in people not being truthful. Even though an extensive integration of automation and IoT, the absence of secure enough hardware and software as indicated by Kahn and Salah (2018), will still make a potential framework vulnerable to attacks and manipulations. The fact stays that it will always be dependent on a human to some grade, although the use of blockchain will improve the security significantly (Kshetri 2018).

6.2.1. Consumer awareness

A trend that has been identified across the interviews is the increasing consumer awareness, both in what the consumer eats and what information the consumer demands about the products they buy. The consumer is getting more conscious of origins and certifications. This calls for a change in how the FSC operates, what information that has to be provided by the actors and in what way the information should be delivered. EC (178/2002) and EC (2014) indicates the need of proper labelling, an expectation that blockchain technology can respond to (Abeyratne & Monfared 2016).

As previous studies have shown, the information asymmetry aligns with the stakeholders' power within the supply chain. This is also the case in this research. The dairy manufacturer and the distribution company have less power than the wholesaler, which is why they do not take initiative for a greater transparency. Blockchain technology enables the possibility of trustfully information sharing among all supply chain members in a secure way (Sarkis et al. 2011; Sayogo et al. 2015). Sarkis et al. (2011) suggests certifications as a solution of the information asymmetry but this study shows that blockchain could add a new dimension of information balance with a greater trust into the shared information. Empirics confirms that the members of the case FSC are willing to adopt a solution if it is available. The blockchain technology is independent of physical, cultural and social distances, reducing information asymmetries and enabling global collaborations (Kshetri 2018; Sarkis et al. 2011). However, there will still be a need of someone to coordinate the collaboration of setting the rules of the framework to be used.

6.2.2. Certifications

The perception of the Swedish milk industry is that there are strict regulations regarding manufacturing and processing in comparison to other countries with large scales of the industry, just as European Commission (2016) reported. Hence, leaving the Swedish industry quite safe with not many local scandals. None of the respondents says they have been involved with any scandals or cases where major actions or precautions has been taken. Personnel in the supply chain are trusted to report in case of any abnormal measures, e.g. temperature in distribution centre, which otherwise could be a source to deviating products with potential risks at consumption. However, in a global perspective the world is still facing food scandals within the milk industry, causing a need of improvement in trust among supply chain members, something that blockchain technology provides (Kshetri 2018; Lin et al. 2017).

All the actors, except the wholesaler, only follows the required standards provided by government, law and buyers. As Chen et al. (2013) describes the wholesaler has developed their own "code of conduct" for their suppliers that has to be fulfilled in order to be able to deliver to the wholesaler. The wholesaler has one employee only working with auditing that suppliers satisfies required standards. This initiative is taken to ensure food quality and food safety. The blockchain could support the work of ensuring product quality and securing certifications (Tian 2017). Fulfilling complex standardizations such as ISO

22000 is believed to be time-consuming and costly. The dairy manufacturer does not see the motivations and value of optional certifications (Bosona & Gebresenbet 2013; Pizzuti & Mirabelli 2015) or traceability systems, as supported by Hoolmé (2012), small actors need to have simplified versions of standardizations in order to have the possibility to satisfy them. Certifications could be managed and maintained in the blockchain enhancing trust among parties and stakeholders in the supply chain. Having certifications and standards included on the blockchain will enable the whole supply chain to have better visibility into their products quality. One of the foundations of blockchain technology is the distributed approach, taking away third parties for acceptance, an approach that would be translated into certifications being unnecessary since the blockchain itself would show all the information needed instead of a certification in a more trustful way (Korpela et al. 2017). Although the purpose of certification organizations is to collect and form standardizations for all the members in the supply chain.

Further on, a blockchain framework for the food industry is believed to develop into a standard, as GS1 has formed several standards to enable effective information sharing (Lindholm 2018; GS1 2018b) within a supply chain of the food industry. As certifications and standardizations implementations already are seen as time consuming and costly by small actors, it is important to make the framework easy to use and implement.

6.3. Infrastructure

In several interviews it is concluded that given the perspective of getting access to more data and information from the rest of the supply chain it would provide opportunities and benefits to the stakeholder of perspective.

6.3.1. *Information flow*

It is identified from literature that small-scale dairy plants often have low grades of documentation (Njage 2018). The empirical findings reveal a more extensive documentation, though this documentation is mostly handled manually which nevertheless result in hindrance of implementation of an overriding food safety management systems or traceability system. However, there is a lack of documentation within the distribution company which indicates an information asymmetry in this specific point (Sarkis et al. 2011; Sayogo et al. 2015). The risk of documents to go missing is increasing the more manually handled they are, meaning unnecessary cost for the case companies (EC 2017). With the use of blockchain to improve the information flow, paper documents will be reduced resulting in saving time and money (Abeyratne & Monfared 2016; Kshetri 2018; Lindholm 2018).

6.3.2. Traceability system

In the interviews it is discussed how a blockchain traceability framework should be designed and what framework that would be preferable to use. It is clear that the knowledge about possible solutions is too vague to be able to give a detailed and insightful answer.

Both empirics and theory indicate a development towards an extended use of traceability systems. During the interviews several strategies were identified with the aim of enabling a higher level of traceability. One of the respondents has been engaged in a project together with a coffee company for providing a solution to trace the coffee bean through the supply chain. The aim of the project was to optimize the chain and minimize the product shelf life. However, evaluations showed that traceability also could be targeted with the solution. A large food group in Sweden implemented a traceability solution called Graphical Lot Tracker with the aim to provide the possibility to track and trace different ingredients and products. It turned out that the solution also was helpful following the business flow. It was discovered trough the empirical findings that a traceability solution not only can be used to track and trace, but also to optimize and control the business flow. Not only does a traceability system cut costs (Dabbene et al. 2014), it can be used for efficient quality management (Xiaoshuan et al. 2013; Dabbene et al. 2014; Allata et al. 2017; Pizzuti & Mirabelli 2015) by utilizing the blockchain technology for a traceability system. It also enables the possibility of a deeper understanding of efficiency, business processes and working with a proactive approach with a pre-warning and CTP system within the traceability system (Abeyratne & Monfared 2016; Kshetri 2018; Khan & Salah 2018; Tian 2017). However, a challenge that has to be faced is that barcodes only provide information about the specific item and does not include the batch number connected to the milk package, leading to a lack in matching and tracing the physical product with a batch number on a specific entity.

7. Conclusions

Following chapter aims to present the main conclusions of the study and the contribution to theory is pointed out. Lastly, some managerial implications to the case actors are given and suggestions for further research are discussed.

In the beginning of the study, theory was reviewed to find relevance to the research and provide the basis for the qualitative data collection and further literature review. The data collection consisted of interviews, observations and additional literature complementing each other with the purpose of proposing answers to the RQ's. Theory, empirics and case analysis was iterated until conclusions could be made and the research questions could be answered as well as solid suggestions of potential cost and environmental savings could be made.

This study proposes a framework which can provide a common information platform with transparency, security and trust for all the members in a supply chain. The framework can enable quicker handling of product recalls from links downstream or after analyzes which will not only deal with issues regarding resource use but foremost address food safety.

Since blockchain is a technology that is providing opportunities for collaborations there has to be a collaborative framework. This study provides a suggestion of a possible framework. However, the framework is not tested nor is it investigated if it is welcomed by the members of the supply chain. The framework has to be user-friendly, otherwise it plays a big risk that it will not be used.

One of the main conclusions to be drawn is that even though the technology for an immutable and easy accessible system which can provide greater transparency and increase trust within the supply chain, such as the blockchain technology, it is still immature in the context of FSC's. However, one of the biggest challenges is to develop a culture which promotes collaborations, information sharing and standardizations which are easy to adopt. For supply chain actors to be willing to collaborate and to put time and effort into new implementations, it is important to find the actual value for every stakeholder.

It was also found that savings in the case of a product recall could be made in both monetary terms and environmental. However, the largest savings would be made if the different batches from different farms could be separated from each other throughout the manufacturing process, resulting in even more traceability potential and pinpointing affected products.

7.1. Contribution to theory

This master thesis contributes by providing empirical data and a deeper understanding on how blockchain technology can be used as a framework for increased transparency and traceability opportunities in a FSC. This study attempts to address and meet the requests expressed by Saberi et al. (2018) and Walker (2018); to mature theory in the area and develop frameworks that can help find best fit standards for increased traceability, transparency and information flow in supply chains. However, as Abeyratne and Monfared (2016) addresses several benefits with blockchain technology, not including the challenges of collaboration issues between supply chain actors, that was discovered in this study.

7.2. Managerial implications

In the case perspective our result seems to suggest that the initiative for taking the step towards a more digitalized supply chain, e.g. via blockchain technology, should come from the manufacturer because they are the ones having the main control of the quality and legal responsibility. Though, the one developing and managing the implementation could somewhat be an external consultant company or other external actors providing services for the FSC. This is due to the required technological expertise. In a bigger and more complex FSC handling several products, the initiator for a blockchain implementation should rather be the wholesaler.

Evaluating the results in chapter 4, looking at Figure 8, Figure 11 and Figure 13, several target areas in the information flow of the case FSC are identified to be manually handled. These areas can be object for efficiency improvements by digital automation as shown in Figure 18, Figure 19 and Figure 20 in Appendix 3. Table 10, Appendix 3, gives an explanation of the suggested improvements in the information flow at each case FSC actor.

A recommendation to the distribution company, to meet the continuous change in business operations, is to move towards reducing the amount of manual processes and adopting a more digital approach. This recommendation is based on the findings that some customers already demand digital handling of their products and the assumption is that even more actors in the food industry will develop towards a higher grade of digitalization in the future.

In order to complete the cold chain, the retailer should involve themselves in the on loading of milk from the distribution company and secure the right temperature at delivery. This can be done with digital temperature devices that measures the temperature of a package.

The wholesaler is the actor within this case study with the most power and resources. Although the manufacturer is proposed to be the initiator for a blockchain traceability system implementation, the wholesaler is outside this specific case working with several more FSC's, which gives them power to put higher demands on the actors further up the supply chain and a better starting position for creating standards for the use of a blockchain framework. In order to follow the market development, they should consider looking into business processes that encourage collaborations in supply chains and offers aiming to meet the increasing stakeholder demands on traceability and increased product specific information.

7.3. Future research

It has been sought to find the value adding aspects of blockchain technology in the context of the study. However, due to the lack of knowledge of the technology in general, it is difficult to give concreate answers to this. A recurring thought about the value creation of blockchain is if it could be furthered used for creating more effective supply chains by providing more correct prognoses due to the sharing of more data. Also, it is important to investigate the possibilities and uses of the technology in the context of supply chains in order to find the clear added values to each and every stakeholder. To address this, it is suggested that studies are done including the entire supply chain, from the farmer to the consumer, as well as studies done individually at each actor to find their specific areas of value. A Life cycle analysis is suggested for investigating this further.

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9. Appendices

9.1. Appendix 1

Table 9: Summary of current technology used in the supply chain and examples of technology that can be utilized in the proposed framework.

Layers	Categories	Currently used technology	Example of technology to be used
Database	Distributed	-	Apache Cassandra, Cloud based storage; EPCD
	Decentralized	-	BigChainDB, Storj
	Centralized	SQL, FTP	SQL, FTP
Blockchain	Public -Open	-	Bitcoin, Etherum
	Public - Permissioned	-	-
	Private - Open	-	-
	Private - Permissioned	-	Hyperledger
	Consortium	-	
Master administration Software	Digital	Movex/M3, Excel	Movex/M3, Excel, Custom Developed Data collection application
	Analogue	Paper documentation	-
Supportive administration software	Digital	WebMethods, OEBAS, Visma, Relex, Conille POS, Denso, Birk	WebMethods, OEBAS, Visma, Relex, Conille POS, Denso, Birk, tracking systems, API, LAN, EPCIS, internet, Wireless internet (GPRS, 3G, 4G), Short wireless connection (Bluetooth, Zigbee, NFC (Near field communication))
	Analogue	Paper documentation	-
Hardware	Devices	Handheld computers, scanners, computers	Handheld computers, computers, scanners, smartphones

	Capture technology	Barcode	QR, RFID, GPS, barcode, WSN, sensor, Retina scan (blood scan), Fingerprint scan, OCR, RTLS, Alphanumerical code, NFC
Physical flow	Product	1 package of milk	1 package of milk
	Perception technology	Barcode	QR, RFID, GPS, barcode, WSN, sensor, EPS, PLU, EAN

9.2. Appendix 2

Interview guide A: today/future/visions/possibilities/strategies

This is the interview guide for understanding the food supply chain operations and situation today in the selected case as well as future possibilities and visions. This guide will be used to interview professionals working in the supply chain with best knowledge of the everyday operations and organizational structures and strategies regarding the topics; Supply chain, Traceability, Food Waste and blockchain.

Instructions

This interview will be semi-structured, there will be a fixed set of questions to be answered with room for interpretations and follow-up questions. The interview is believed to take 45-60 minutes and will be audiotaped if permissioned by the respondent, additionally there will be notes taken during the interview. This interview is made for a master thesis and the interviewers will introduce themselves and the master thesis subject at the beginning of the interview session. Before publishing the respondent will have the opportunity to examine and confirm the interpretation of the collected data.

Framework for interview and discussion

Background

1. What's your name?
2. What's your title?
   a. How long have you worked within the company?
   b. Tell us about your roll at the company?
   c. How does a normal day at work look like for you?

Supply Chain

3. What does your supply chain look like today?
   a. How much is manually handled?
   b. How much is digitally handled?

4. How does your information flow look like?
   a. How much and what data do you share with other actors within the supply chain you´re operating in?
   b. How is data collected, stored and shared?
   c. What databases do you use? Is it centralized or provided by an external paty?

Traceability

5. How do you value traceability within your company?
   a. Is it something you prioritize in your business operations?
   b. Do you have any ideas how the traceability can be improved by your company?
   c. Are there some actions that could be improved?
   d. Are there any digital hardware or software that could be improved, replaced or implemented?

6. How are you working with traceability today?
a. What actions are made?
b. How does your contact with suppliers and buyers/customer look like?
c. Are any certifications or standards used/third parties involved in your business?
d. Are any digital hardware used?
e. Are any digital software used?

7. What actions are made in case of a product recall?
a. is there any documentation over what routines there are in this case?

8. What trends can you see for the food sector to improve traceability?
   a. Is this something that you think you could adopt in the future?

9. Have your company historically done any projects to increase the traceability?
a. What was the projects?
b. Who made the initiative?
c. How was it performed and implemented?
d. What was the results?
e. Which were the difficulties?

10. Do you have any projects in the pipeline to improve traceability?
a. How do you work with external analysis (omvärldsanalys) of trends in technique of traceability and digitalization?
b. Do you follow news online/in papers?
c. Do you attend to different events?

11. Do you collaborate with any other members of the supply chain to increase the traceability?

Food waste

13. Do you know how much food waste that occurs in your business?
a. Do you have any stored data for us to take part of regarding the food waste?
b. How do you save the data? Alternatively - How would you like to save the data?

14. How does food waste affect your business?
   a. Have you detected an increase or decrease of food waste in your business?

15. How are you handling food waste?
   a. Do you have any strategies for food waste?
   b. Do you have any ideas or thoughts how you could change your strategies or develop efficient strategies to prevent food waste?

16. Do you have any ideas on how to decrease the food waste in your business?
   a. Do you have any bottlenecks that generates a lot of food waste?
   b. Is there any special requirements to reduce the food waste in your case?
   c. How much food waste do you think you could cut?

17. What's your thoughts about waste in the future?
   a. What opportunities and challenges can you see?

Blockchain

18. Have you heard of blockchain?
   a. Do you see any use of the technique to your company?
   b. Have you considered an implementation?
   c. What would be the benefits to your company if implemented?
   d. Do you see any difficulties or consequences?
   e. Do you believe that your business model (we might need to add some kind of explanation here) have to change with the implementation of blockchain?
   f. In what way?

Interview guide B: technique/implementation/

This is the interview guide for understanding how the blockchain technique can be used within a food supply chain. The respondents are professionals with experience of either blockchain technology, integration of traceability systems or future trend experts related to the topics; Supply chain, Traceability, Food Waste and blockchain.

Instructions

This interview will be semi-structured, there will be a fixed set of questions to be answered with room for interpretations and follow-up questions. The interview is believed to take 45-60 minutes and will be audiotaped if permissioned by the respondent, additionally there will be notes taken during the interview. This interview is made for a master thesis and the interviewers will introduce themselves and the master thesis subject at the beginning of the interview session. Before publishing the respondent will have the opportunity to examine and confirm the interpretation of the collected data.

Framework for interview and discussion

Background

1. What's your name?

2. What's your title?
a. How long have you worked within the company?
b. Tell us about your roll at the company?

Supply Chain

3. What experience do you have with food supply chain performance and operations?

Traceability

4. What experience do you have with food traceability?
a. Do you know of any efficient ways to work with traceability?
b. Do you know of any successful cases regarding traceability tools and strategies?
c. What do you believe is required to obtain high level of traceability?

Food waste

5. How much insight do you have in waste within dairy supply chains?

6. Do you know of any best practises strategies for reducing food waste?

7. Do you have any other suggestions or ideas on strategies for reducing food waste?

8. What's your thoughts about waste in the future?
a. What opportunities and challenges can you see?

Blockchain technology

9. What experience and skills do you possess about blockchain technology?
a. Have been involved in a project with blockchain technology?
b. Do you have any other good examples of successful projects?

10. What possibilities do you see with blockchain?
    a. How can blockchain be used within a supply chain, specifically food/milk supply chain?
    b. How can blockchain be used to obtain traceability in a food supply chain?
    c. How can blockchain be used to reduce food waste?

11. What challenges do you see with blockchain?
   a. What are the requirements for implementation of a blockchain in a milk/food supply chain?
   b. What do you believe are other best practice technologies that compete with blockchain in a food/milk supply chain?

12. What kind of blockchain would fit a food/milk supply chain to obtain traceability?
   a. How should the framework be set?
   b. Should it be a public, private or hybrid blockchain?
   c. Should it be distributed or decentralized?
   d. What data storage technique is preferred?
   e. What technique for identification should be used?

13. Do you believe that business models have to change with the implementation of blockchain?
   a. Who owns the data?
   b. Who will have the power of the data? Thinking of optimization and analyzing.
   c. Is there a need for regulations/certifications?

E-mail to respondents:

Hej!

Tack för att du valt att delta i vår studie!

Här kommer en introduktion till hur din kommande intervju kommer att läggas upp samt vilka ämnen vi kommer att beröra.

Det är vi, Rebecca Åquist och Anna Holmberg som kommer att utföra intervjun som beräknas ta ungefär 60 min. Med ditt godkännande önskar vi göra en ljudupptagning av intervjun. Vi kommer även föra anteckningar under intervjun.

Vi kommer att ställa frågor kring hur varuflödeskedjan för ett paket mjölk ser ut samt hur arbetet med matsvinn och spårbarhet av mölk ser ut.

Efter granskning av intervjun kommer du att få möjlighet att ta del av våra sammanfattningar för att konfirmera att rätt tolkningar har gjorts.

Har du några frågor eller funderingar inför din intervju svarar vi gladeligen dig antingen via mail eller per telefon.

Med vänliga hälsningar,

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Anna Holmberg

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9.3. Appendix 3

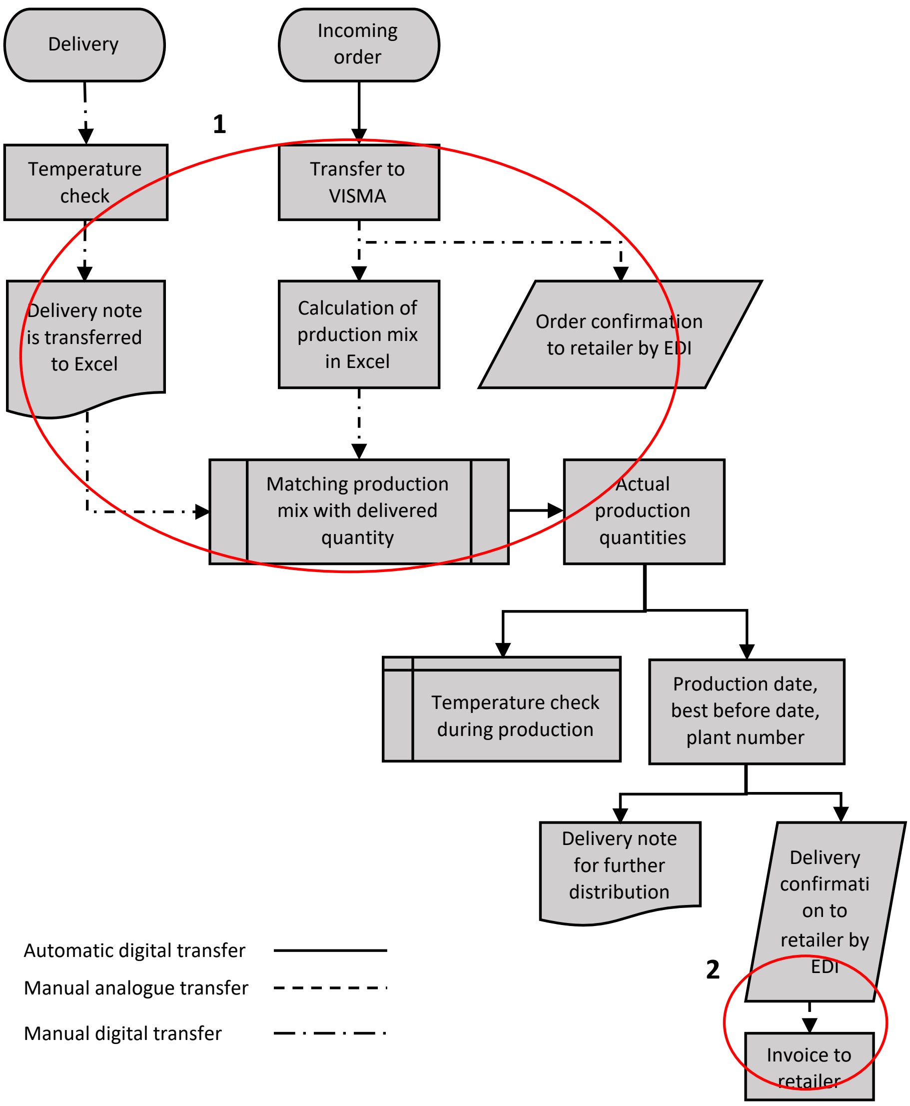

Figure 18: Target areas for improvement for the dairy manufacturer information flow.

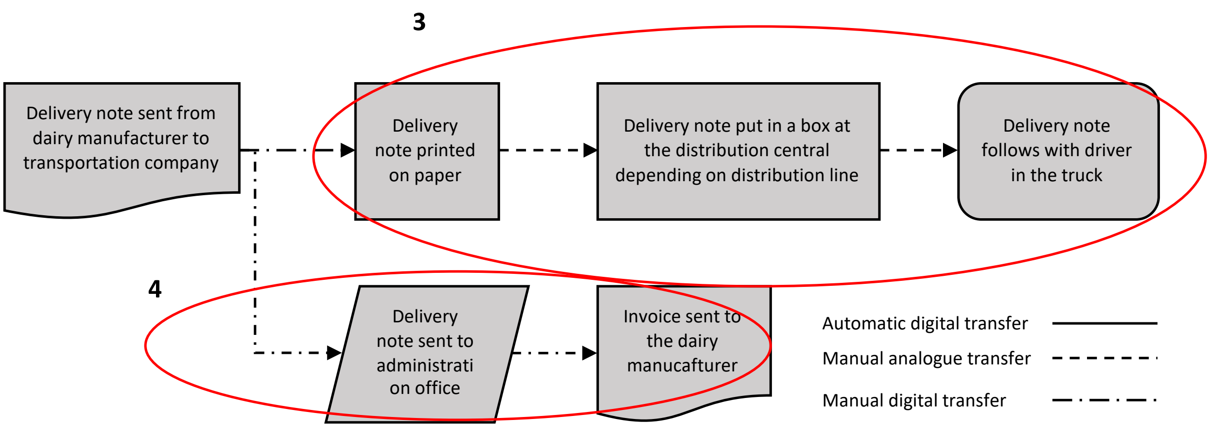

Figure 19: Target areas of improvement for the distribution company information flow.

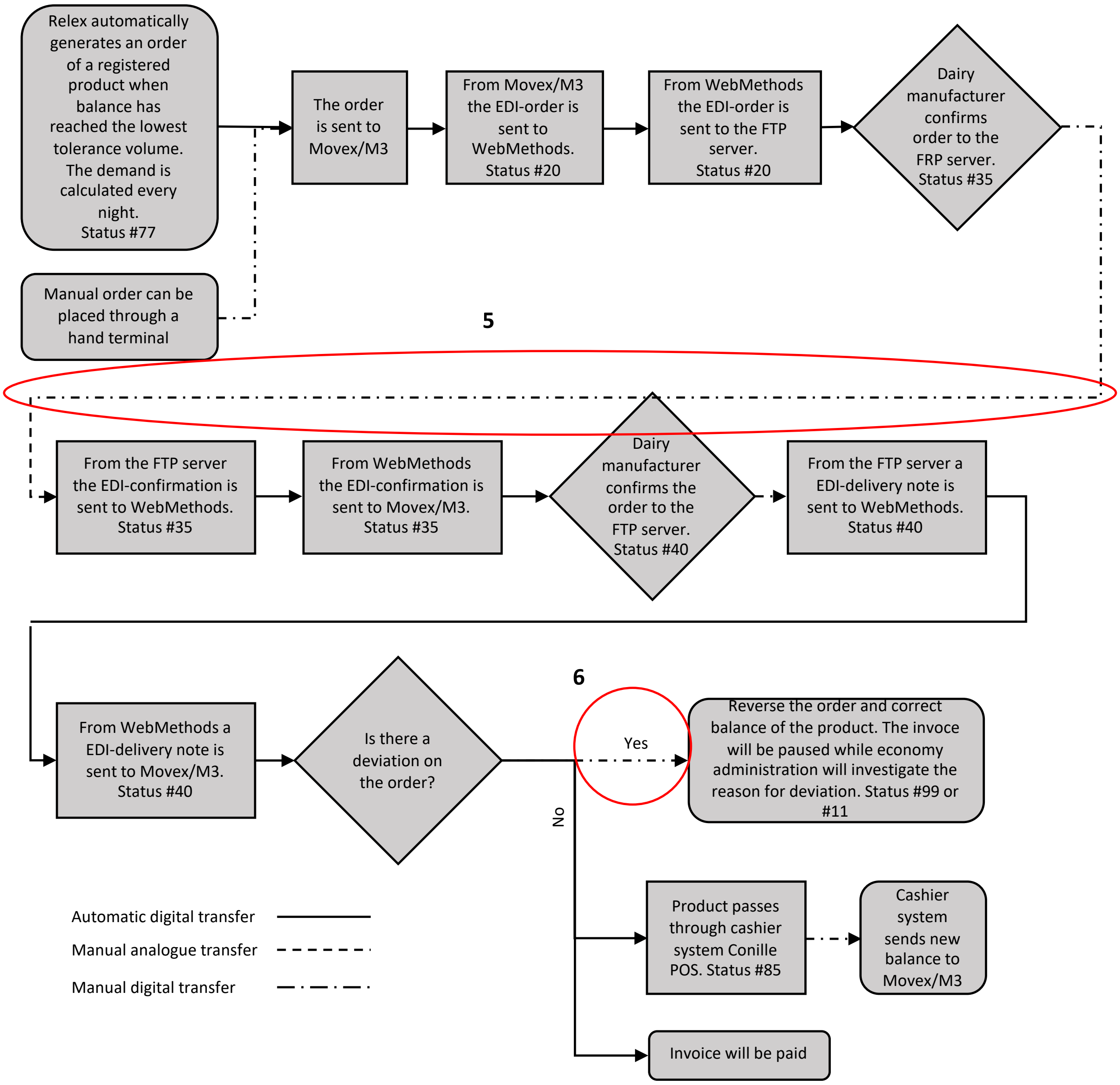

Figure 20: Target areas of improvement for the retailer and wholesaler information flow.

Table 10: Explanations of target areas of improvements from dairy manufacturer, distribution company, wholesaler and retailer information flow.

Problem area No.	Problem	Improvement
1	Manual digital handling	Transactions could be digitally automated
2	Manual digital handling	Transactions could be digitally automated
3	Manual analogous handling	Transactions could be digitally automated
4	Manual digital handling	Transactions could be digitally automated

5	Referring to problem area 1 and 2	Transactions could be digitally automated at the manufacturer
6	Hidden statistics due to automatic order confirmation	Scan products when delivered at the retailer in order to confirm the delivery