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The Potential of Blockchain
in Supply Chain Logistics

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Abstract

Today, it is important to understand how logistic systems can become more efficient and effective through increased digitalization and information sharing, as the exponential development in technological advancements during the recent decade has opened up new opportunities for digitalization of businesses.

Blockchain is considered to be one of the most disruptive technologies of modern times. (Dinh & Thai, 2018) Information generation and information sharing are important for integration of partners in a supply chain, and for the logistics in a supply chain to function efficiently. To understand how blockchain can impact information sharing in supply chains and logistics, the purpose of this thesis is to explore the potential of blockchain in supply chain logistics.

The thesis focuses on explaining blockchain to make it approachable and easy to understand. The thesis is divided into two parts, the technological part, with comparisons to other digital technologies in order to pinpoint how blockchain relates to other technologies, and the information sharing part of the supply chain. With that foundation, the analyses look into the contributions blockchain can provide, how it compares to traditional IT-systems for information sharing and what to consider before and during an implementation of a blockchain protocol in a supply chain.

To categorize information sharing, important aspects were chosen from literature and validated through supply chain managers from companies operating at different parts of supply chains and different industries. The connection between blockchain and supply chain has been poorly documented, therefore, in order to evaluate the actual potential of blockchain, interviews with four highly experienced blockchain experts were conducted.

The research resulted in the conclusion of how important it is to conduct an investigation of what blockchain is intended for, and what value it adds to all parties involved, before starting the technical implementation. Furthermore, this research concluded that the possibility to use blockchain both independently and in combination with other technologies in a chain, to provide fully automated processes of disseminating and storing information, provides a great potential for further development of blockchain in the supply chain industry.

Through the characteristics which the technology possesses, such as, consensus, traceability (provenance), immutability, finality, decentralisation and persistency, blockchain can have a big impact on information handling in many industries. Companies should however consider whether a blockchain solution is necessary, since the complex and decentralised nature of the technology demands involvement from multiple parties and comes at a substantial cost.

A supply chain aims to maximise added value, which correlates well with the opportunity blockchain presents of eliminating the need for unnecessary intermediaries, streamlining the information flow, while simultaneously building trust.
Acknowledgements

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Robert Michalak and Filip Micklin.
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<td>Automatic Identification and Data Capture</td>
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<td>CPS</td>
<td>Cyber Physical Systems</td>
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<td>DLT</td>
<td>Distributed Ledger Technology</td>
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<td>IaaS</td>
<td>Infrastructure as a Service</td>
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1 Introduction

The following chapter presents the background to the thesis, the purpose of the study, its scope and delimitations and the main research questions that will help to fulfil the purpose of the study. There is also reading instructions for different readers.

1.1 Background

Increased globalization has led to increased complexity for companies. This increased complexity combined with the technological advantages in recent years has led the industry towards the ongoing fourth industrial revolution, also called Industry 4.0. (Ustundag & Cevikcan, 2018) This development in industry creates greater demands on logistics to face the changes and increased complexity on the markets. To stay competitive, the logistics need to evolve, and like in the industry, this progress happens with digitalization and with new technologies as a foundation.

The exponential increase in technological advancements during the recent decade has opened up for new opportunities. To investigate the potential of new digital technologies the Logistics Department at Linköping University is part of a three-year project. The project strives to identify how logistic systems can become more efficient and effective through increased digitalization and better information sharing.

Information generation and information sharing are important for integration of partners in a supply chain. The willingness to share information, what technological possibilities exist, what information is shared, and how companies utilize the information are therefore essential topics for the progress of information sharing and its benefits.

Blockchain is considered as one of the disruptive technologies of modern times. Today, many companies have heard of blockchain but are unsure of what it is, how it works, what fields of application the technology has, and how their business can benefit from implementation.

A common misconception is that blockchain and Bitcoin are the same thing. This is however not true. The technologies originated together, and Bitcoin uses blockchain for its bookkeeping, however, cryptocurrencies today are only one of many applications that blockchain can be used for. (Kranz, 2018)

Blockchain has the potential to be applicable in many industries, not only the financial services industry, where most attention has been directed so far. New use cases emerge continuously in multiple industries, and some of them are: managing electronic health records, strengthening data privacy, ending counterfeiting in the supply chain. (Kranz, 2018)

Another important application of blockchain is the smart contract which can operate and automate business processes in a fully decentralized way. (Kranz, 2018) This combined with the opportunity of establishing identity through the cryptographically created keys and the possibility to transfer value on the blockchain creates the opportunity to eliminate the middle man, and thereby increase efficiency. (Marr, 2017)

There have been some recent applications of blockchain within supply chain logistics. To increase traceability and food transparency after the outburst of E. coli in the United States, that resulted in five deaths, Walmart and nine other companies founded the Food Trust group
who use the Food Trust blockchain. (Nash, 2018) Arla is also launching Arla Milkchain for a more transparent milk production process in Finland.

There seem to be many applicable areas for blockchain capabilities that can contribute to supply chain logistics. The challenge lies within identifying where and how.

1.2 Purpose
The purpose of this thesis is to explore blockchain technology and its potential in digitalizing Supply Chain Logistics.

To further the understanding of the purpose it is important to clarify four important terms:

- *Explore*, refers to the investigation of blockchain and its underlying technology, as well as the connections to information sharing within supply chain logistics.

- *Potential*, is both the possible improvements that blockchain can provide in Supply Chain Logistics as well as impediments. More specifically, these improvements and impediments are based upon important aspects of information sharing with blockchain in comparison to current IT-systems.

- *Supply Chain Logistics*, is in this report defined as the three flows that multiple companies manage in a collective network; Information-, Physical-, and Payment flow.

- *Digitalization*, is the integration of digital technologies into everyday life. The literal meaning of digitalization gives an apparent idea of development and technology dependent world, in this case specifically for information sharing within Supply Chain Logistics.

1.3 Scope and Delimitations
For this thesis blockchain was explored and its relation to supply chain logistics as well as to current trends in digital technologies, with the intention of providing an easily understandable explanation of blockchain for those unfamiliar with the technology. To limit the work and concretize the scope of the study, the following delimitation were made:

- The thesis should focus on information flow and not payment- and physical flow.

![Diagram of Supply Chain Logistics](Source: Own illustration)
1.4 Research questions
To be able to make this thesis more approachable to those who are not already familiar with blockchain, a structured, thorough explanation concerning blockchain is necessary, which formed the first research question: What is blockchain?

To further build on the first research question and gain an understanding of how companies can implement a blockchain protocol in their business. A protocol is the way the technology is formed in terms of layout and how it communicates. Therefore, the second research question is formed as: How can companies implement a blockchain protocol?

Depending on a company’s choices on how to adapt a blockchain protocol, its use and benefits can vary. In order to better understand the potential of blockchain and the benefits the technology can have on information sharing for companies within a supply chain the third research question formed as: How can companies benefit from using blockchain?

Together, the questions are used to fulfil the purpose of the study. A further explanation of the research questions, with sub-questions, is presented in chapter 3.3 Breakdown of Research Questions.

1.5 Reading Instructions
Depending on what the reader hopes to gain from reading this master thesis, the authors have a few recommendations on which parts to put emphasis on.

For the reader with limited time, the authors recommend starting from chapter 5: What is Blockchain? The chapters from 5 and onwards gives a brief summary of the theoretical framework, including a simplified description of blockchain. Each question is answered, before reaching the conclusion and reflection which the authors strongly recommend reading, especially the conclusion.

For the readers looking to advance their knowledge in both supply chain and blockchain, the authors strongly recommend reading the theoretical framework meticulously to truly grasp the technology of blockchain. The methodology is of interest for readers looking to conclude similar research, or those interested in how the work has been conducted.

For company representatives considering implementing a blockchain solution the authors recommend more than one representative to read the report. The reason is to get an immediate discussion going regarding the introductory steps towards a blockchain solution.
2 Theoretical Framework

The following chapter consists of the conducted research and is divided into three parts, Logistics, Digital Technologies, and Blockchain. The Theoretical Framework include research of literature in regard to these three parts. The first part, Logistics, is mostly focused around Supply Chain logistics and more specifically the challenges of information sharing. The second part, Blockchain, aims to give a basic understanding of what blockchain is, the functionality of the underlying technology and examples of utilization areas. The third part, Digital Technologies, focus on describing different current digital trends used to handle and share information.

2.1 Logistics

The Council of Supply Chain Management Professionals (2018) defines logistics, or rather logistics management as:

“Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements.”

The modern understanding of logistics demands a process-oriented management of all elements in a complete cycle, where the utilization may be considered a competitive advantage or a way of rationalizing your operation. The competitive advantages generated by logistics can create new strategies and possibilities giving an edge in comparison to the competition. Indirectly, the same goes for the rationalization of the operation, since a rationalization creates a more efficient operation which in retrospect creates sustainable competitive advantages. (Gleissner & Fenerling, 2013)

Consequently, logistics is about planning and implementing that plan. Furthermore, it is essential to control the results and whether they fulfil the set targets/demands. In order to reach the targets, it is crucial to gather and utilize information from the supply chain. The process in gathering and utilizing that information is a big part of the challenge with logistics. The information in itself contributes to the main purpose of logistics, offering a cost-effective delivery service. (Oskarsson, et al., 2013)

As globalization and logistics tend to go hand in hand, new challenges arise as supply chains become longer and more complicated creating a challenge for companies to optimise their Supply Chains. (Gleissner & Fenerling, 2013)

2.2 Supply Chain

One of the biggest changeovers in modern management was realising that competition does not occur between individual entities, but between different supply chains (Lambert & Cooper, 2000). Companies are forced to act as fast innovators to adapt to their consumers while still competing on the three traditional dimensions, quality, time and cost (Sanders, 2012).

This has made Supply Chain Management a revolutionary business model. Supply Chain Management is the design and management of the product-, information-, and value flow throughout the whole supply chain. It is a very complex business model that handles the coordination and management of all activities within a supply chain. To apply Supply Chain Management, it is important to have good understanding of supply chain. (Oghazi, et al., 2018)
A supply chain is the network of all units that contribute to the production or delivery of a finished product to the end consumer. The typical supply chain usually consists of customers, retailers, wholesaler, manufacturer and a raw material supplier. (Chopra & Meindl, 2007) It is however important to recognise the big differences between different supply chains and that most generic theoretical descriptions are inaccurate in comparison to the practical supply chains. Furthermore, at first glance, it is easy to mistakenly think of the coordination within a supply chain as simple. When in reality, the coordination that has to occur is between, in some cases, hundreds of contributors, which combines into very complex networks. The goal with a supply chain is to maximise the added value. Added value is defined as the value added in a supply chain from raw material to finished product. (Chopra & Meindl, 2007) The optimisation of this process has become increasingly important, as the financial pressure put on companies has increased. In a globalised market, the competition has increased while consumers have become more demanding. Many of the functions, that serve the purpose of achieving the consumer demands, have shared responsibility in different processes, for example forecasting. It is quite often here the biggest challenge with a working supply chain lies. This is because different parts of the supply chain have different goals and, in some cases, compete for the same resources. This has a negative effect on the trust and willingness to a closer co-operation. (Johnson & Borger, 1977; Ellinger, et al., 2006) Although companies might trust each other, they have to be able to connect somehow.

2.2.1 Supply Chain Integration

In a study made by the authors Frohlich & Westbrook (2001), a closer investigation of the supplier and customer integration in 322 cases showed five different integration strategies. These strategies showed both the degree of activity as well as the direction towards suppliers and customers and are classified into inward-, periphery-, supplier-, customer-, and outward-facing. (Frohlich & Westbrook, 2001)

![Diagram showing integration strategies](image)

**Figure 2:** Shows the direct correlation between externally integrated systems and internally integrated systems. Source: Own illustration based on (Frohlich & Westbrook, 2001)

Before companies can develop shared operational activities, the need has to be identified and accepted. Frohlich & Westbrook (2001) suggest a Supply Chain Integration tactic, where the literature suggests manufacturers employ one of two integration forms. The first one involves coordinating and integrating the forward physical flow of deliveries in the supply chain. This is often likened to the concept of just-in-time that is considered to be an overall organizational
phenomenon. (Sakakibara, et al., 1997) The other integration form involves the *backward* coordination of information technologies and the flow of data from customers to suppliers. This integration is becoming exponentially more important as a competitive strategy in the rapidly evolving retail industry. (Li & Chen, 2017)

![Diagram of Supply Chain Integration](Image)

*Figure 3: The figure illustrates the two integration forms. The "information integration" arrow is a backward coordination of information technologies and the flow of data from Customer to Supplier. The second one is the forward physical flow of deliveries. (Source: Own illustration based on (Slone, et al., 2010)*

The conclusion reached by Frohlich & Westbrook (2001) was that companies with the greatest arcs of supplier and customer integration are most likely to see the largest improvement in performance. Another interesting conclusion made was that a “weak” supply chain is hurtful to performance since a chain is as strong as its weakest link (Frohlich & Westbrook, 2001).

Since Supply Chain Integration is between companies in regards of alliances, information sharing, and process coordination, it is important to investigate and express the importance of inter-organisational Supply Chain relationships (Wang, et al., 2018).

2.2.2 Internal- & external integration

Companies today face the challenge of both internal- and external integration. According to (Troyer & Cooper, 1995) companies have to successfully integrate on various levels of the Supply Chain to unlock the full potential of Supply Chain Management (SCM). Therefore, for a Supply Chain Integration (SCI) to succeed both internal processes within the company as well as external processes connected with suppliers and customers have to be successful. (Schoenherr & Swink, 2012) In fact, to attain the desired benefits with information sharing activities, a high level of integration is required for buyers and suppliers. (Williams & Tokar, 2013)

The difficulties in quantifying the impact of SCI on performance comes from unclear definitions as well as inadequate measurement tools relating to SCI, performance or both (Fabbe-Costes & Jahre, 2008). Despite the vast research within SCM, the definitions are poorly established, and the measurement-scales are lacklustre in construction for SCI. The authors Moyano-Fuentes, et al. (2016) argue that this is partially due to the inclusion of the two integration components, internal and external. This causes a problem as many definitions have a focus on one of the two. Continuing, the authors express the problematics of the variance in scope, in some cases only extending to a nearby dealer while in other cases spreading to different levels in the supply chain. According to the same authors, this might be due to the loose definition of integration. Different authors choose to define and categorise integration differently, which creates a non-coherent perception of what metrics are included. However,
a great deal of emphasis within supply chain literature is on the close unity of Supply Chain Relationship (SCR) and SCI. (Tsai & Hung, 2016)

2.2.3 Importance of Supply Chain relationships
For a supply chain to be successful it takes coordination of activities, collaboration in planning, and sharing information among the companies involved within the supply chain, so that they can improve together. (Sanders, 2012) Furthermore, according to Sanders (2012) the relationship aspect of SCM is the most important one, since it affects all areas of the supply chain and can have a substantial impact on the performance. The author continues to argue the importance of relationship management since information technology only provides the possibility to share information, but the relationship is what drives the exchange. Managing the SCR includes managing relationships between people and issues that include respect, trust, agreements, negotiation, joint ventures, contracting and even conflict resolution. In another study, the authors Tan, et al. (2006), performed an investigation to find the main underlying factors that contribute to the management of a global supply chain from the perspective of small and medium-sized enterprises (SME). The conclusion made was that the factors affecting SCR the most were sharing of information, expertise, trust, communication, jointly established objective and management commitment.

Sanders (2012) means that SCR is divided into two dimensions, scope and criticality. The first one, scope, is the degree of responsibility assigned to the supplier. Where the relationship is defined by the provided services from the supplier in terms of numbers. Criticality on the other hand is based upon the importance provided.

In a literature research conducted by Hudnurkar, et al. (2016) information sharing showed to be the most important aspect of supply chain collaboration. The research reviewed 69 anonymized research papers and had a main purpose to investigate the factors affecting Supply Chain Relationships.

2.2.4 Information Sharing
According to Barratt and Oke (2007), information sharing is an activity that leads to more effective supply chains by providing visibility. The concept of information sharing is often divided into two different categories. The first one is tracking information regarding the merchandise. The technology used up to date has been radio frequency identification (RFID) and bar code applications. The second category is referred to as planning information and can be either demand-related or supply-related. Demand-related information shared between customers and suppliers include customer orders, point-of sales data, planned orders, forecasts and available stock. (Mattsson & Jonsson, 2013) In a case study conducted by Bartlett, et al. (2007), by using transparency as a measurement of visibility, they found that exchange of the correct information improved the supply chain performance overall. The use of external information may reduce uncertainty and improve coordination. Which might be the explanation to why externally integrated companies outperform non-integrated companies. However, Sahin & Robinson (2002) argue that information sharing in itself does not eliminate the Bullwhip effect, but that coordination among trading partners also is needed. Even further than that, according to Fawcett, et al. (2009) there is a drawback with information sharing. For example, since the standard deviation of demand is higher on a daily basis in comparison to a weekly or monthly, a customer integration can cause a “nervousness” that has a negative performance impact.
Whereas Wu, et al. (2014) examines information sharing from the perspective of social exchange theory, Fawcett, et al. (2007) explains information sharing can be described as a combination of willingness and connectivity.

**Connectivity and Willingness**

In the era of digitalisation, creating information-linked strategic alliances through Information and Communication Technologies (ICT) is decisive for survival of companies (Dong, et al., 2009). The authors Lambert, et al. (2005) point out that connectivity is essential no matter if the focus is around transactions or relationship management. The purpose of connectivity for transactions is to create a flow between the functions in the supply chain and the purpose of connectivity in relationship management is to create relationship between firms at multiple levels.

As mentioned before, information sharing is a combination of willingness and connectivity. According to Fawcett, et al. (2007), willingness is described as whether or not companies will share decision-making information. While connectivity relates to the IT side of information sharing and can be described as to what extent companies are able to collect, analyse, and disseminate information. Although connectivity is a vital part of integration, it is easier to ensure than willingness. Willingness cannot be as easily improved as connectivity where you can invest through new technology updates or employment of experts. Willingness is more about nurturing a relationship and building trust between the companies involved. A common factor hindering a beneficial sharing of information in-between companies is the fact that many companies feel they will be put at a disadvantage if they share their information. (Williamson, 1975)

Fawcett, et al. (2007) also found that companies are more probable to invest in connectivity rather than willingness, even though both are connected to competitive performance. Furthermore, companies that put an effort in both aspects of integration had a significantly better result than companies who only invested in one of the two.

**Accessibility**

The accessibility of information in a Supply Chain depends on how well integrated the information sharing systems are to all parties involved in the Supply Chain and the ability to access information from anywhere in the Supply Chain (Nath & Standing, 2010). According to Nath and Standing (2010), real time information accessibility is motivated due to the need to provide access to orders, inventory and information at multiple points of the Supply Chain, easy access to the required information, create information visibility and storing and accessing human experiences and knowledge.

**Security**

According to the authors of Supply Chain Collaboration and Firm’s performance (Panahifar, et al., 2018), in order to successfully collaborate, companies must be aware of the collaboration enablers. One of the main collaboration enablers is the role of secure information sharing. The importance of security is to counteract for any involved parties in the supply chain to experience leaks of proprietary information. Furthermore, a study conducted showed that the creation of secure information sharing systems can increase trust between partners (Panahifar, et al., 2015).
As the level of collaboration and extent of information sharing increases, the emphasis on security in information sharing does as well. (Smith, et al., 2007) In a high-level information sharing scheme, some partners are concerned about the idea of sharing sensitive data such as financial reports, production planning etc. There is therefore a need to balance information sharing and security to optimize the collaboration. (Panahifar, et al., 2018)

Social Exchange Theory
Wu, et al. (2014) explains that social exchange theory (SET) originally focuses on cost-reward views for individuals and corporate groups to provide motivation for interaction with others. The authors further explain that SET is based on principles for psychological and economical reinforcement surrounding participants behaviour in a social exchange. According to Zaheer & Trkman (2017) the link between behavioural factors and information sharing in supply chains has been made in many studies. However, just a few have derived them from a unifying theory which is important if the challenges of information sharing are to be understood. Both Wu, et al. (2014) and Zaheer & Trkman (2017) use the four SET factors; trust, commitment, reciprocity and power, and investigate their impacts on information sharing as well as individuals’ willingness to share information.

Trust
Trust is one of the most impactful contributing key factors to a successful strategic alliance (Krishnan, et al., 2006). It is defined as a willingness to depend on a partner and characterized by the belief that the partner will not indulge in opportunistic behaviour. (Moorman, et al., 1993; Noteboom, et al., 1997) Trust results in the belief that the other parties in a supply chain will act in good will and accomplish tasks that generate positive outcome for all parties as well as mitigate risks that result in negative outcome (Anderson & Norus, 1990). Furthermore, the lack of trust in a supply chain is the leading cause for unsuccessful partnerships (Su, et al., 2008). In fact, a lack of trust among trading partners creates a negative on transactions costs, as companies feel the need to be thorough on every transaction and draft complex contracts and detailed confidentiality clauses (Fawcett & Magnan, 2004).

According to the authors Das & Teng (2001) trust is divided into two categories, goodwill trust and competence trust.

Goodwill trust
According to the authors Wei & Yucetepé (2013) goodwill trust means that “members believe and expect that the partner concerns about its interest, rather than making use of its frangibility to pursue selfish interest, even in the in the incomplete contract condition.” Goodwill trust is important for all parties in a joint venture, since they have to work as a single entity, creating a need for mutual goodwill feeling about each other as well as integrated systems. (Das & Teng, 2001) However, goodwill trust is not as important when it comes to non-equity partnerships. Non-equity partnerships are for the most part reliant on legal obligations.

Competence trust
Competence trust is however, more important in minority equality alliances. An example used by Das & Teng (2001) is how large pharmaceutical enterprises acquire smaller companies as an investment. Competence trust is essential in order for these large pharmaceutical enterprises to have a substantial return on investment. (Das & Teng, 2001) According to the authors Li, et al. (2012) competence trust is the foundation of goodwill trust. The authors argue that competence trust contributes with the belief that partners will fulfil their contract, the belief
that the partners will maintain a trust relationship stand and the belief that the partners have the ability of implementing cooperation.

Commitment
For companies to become engaged in a supply chain relationship and invest their time and resources, they have to believe all parties strive for an enduring and long-lasting relationship. (Morgan & Hunt, 1994) Furthermore, according to the authors Morgan & Hunt (1994) commitment is defined as “an exchange in partner’s belief that an ongoing relationship with another is so important as to warrant maximum efforts at maintaining it; that is, the committed party believes the relationship endures indefinitely.” Commitment is an essential factor for long-term success in a supply chain as it shows if members are willing to sacrifice short-time benefits for long-time success. Furthermore, the only way that companies maintain this kind of partnership is if they perceive mutually beneficial outcomes from such a commitment. (Chen, et al., 2010)

Reciprocity
Haeussler (2011) argues that reciprocity is a factor that gains more attention with regard to accumulation and exchange of information. Furthermore, Zaheer & Trkman (2017) argue that reciprocity is important in the information sharing context as it means that one partner will be willing to share information with another as long as that partner provides information of the same value in return. Extrinsic rewards and reciprocity work as motivation for willingness to share information as willing people expect to be reciprocated. Furthermore, Haeussler (2011) explains that one party will be obliged to reciprocate to maintain the balance of benefits and contributions. Wu, et al. (2014) explains that reciprocity in the supply chain can facilitate information sharing and that motives for reciprocity emphasize on cooperation and collaboration among partners in the supply chain to pursue common goals. Haeussler (2011) means that in the context of information sharing, reciprocity has two elements. The first is the interest in maintaining a good relationship, which can increase chances of future exchanges. The second is that feelings of guilt and fear of bad reputation arise with those that do not reciprocate, due to the inherent sense of “quid pro quo”.

Power
Wu, et al. (2014) explain that the relative dependence between exchange members can be referred to as power, where power gained by one member can influence behaviour and decisions of other members. According to Griffith, et al. (2006) power has been used to explore channel leadership. Power set forth the parameters for exchange in the relationships, since the power earned by one member is used to direct action. Furthermore, Zaheer & Trkman (2017) explain that power is usually tilted towards one company in a relationship in a supply chain, which give the dominant party the power to determine the format and extent of information sharing. Wu, et al. (2014) argues that members with more resources and power in the supply chain than its partners will execute more power to force them to share information, or pressure them to use inter-organizational systems to share various information online and thereby effectively facilitate collaboration of supply chain activities. In their study, Zaheer & Trkman (2017) explain that power has been proven to be important for long-term supply chain relationships. However, firms can perceive loss of power from sharing information. The authors found that the power of the more powerful partner proved to not affect the willingness to share information. However, the individual might still end up sharing information with the more powerful partner, just not willingly.
Type of information shared

The information in a supply chain can vary widely and it is important to categorise the information to realize the distinct differences in how to share it. Mentzer (2004) The same author expresses how supply chain information can be classified differently, for example, strategical or tactical; logistical or pertaining to consumers. More familiar types of information may be categorized as follows:

- Inventory information
- Sales Data
- Sales Forecasting
- Order information
- Product Ability Information
- Exploitation information of New Products
- Other information (Quality, function parameter of supply chain, plan, etc.)

These types of information differ widely not only in themselves but also in company’s willingness to share. The authors of Information sharing in Supply Chain Management (Lotfi, et al., 2013) have summarized the benefits that information sharing contributes as the following list.

1. Inventory reduction and efficient inventory management.
2. Cost reduction
3. Increasing visibility (significant reduction of uncertainties)
4. Significant reduction or complete elimination of the bullwhip effect
5. Improved resource utilization
6. Increased productivity, Organizational efficiency and improved services
7. Building and strengthening social bonds
8. Early problem detection
9. Quick Response
10. Reduced cycle time from order to delivery
11. Better tracing and tracking
12. Earlier time to market
13. Expanded network
14. Optimized Capacity utilization

As seen above, information sharing among supply chain members can contribute with many benefits to industries. Commonly in supply chains, members may have perfect information about themselves while having lacklustre information about the other members involved, (Razavi & Iverson, 2006) some cases eradicated if the members of the supply chain have the ability and willingness to share information. (Lotfi, et al., 2013) The ever-feared bullwhip effect is the description of upstream variation in a supply chain. According to Lee, et al. (1997) the known causes for the bullwhip effect are: information asymmetry, demand forecasting, lead-times, batch ordering, supply shortages and price variations. The author continues by expressing the importance of information flow in a supply chain in order to decrease the uncertainties within the supply chain, and by the default, the bullwhip effect.
Information sharing not only generates better performance, according to Marshall & Bly (2004) sharing of information also builds and strengthens relationships and social ties among the members of the supply chain.

**Barriers in information sharing**

In a supply chain, members are faced with obstacles in information sharing that are directly connected to connectivity and willingness. According to the authors Lotfi, et al. (2013) some of these obstacles are, confidentiality of the information shared, incentive issues, reliability and cost of information technology, anti-trust regulations, the timeless and accuracy of the shared information, and finally the development of capabilities that allow companies to utilize the shared information efficiently. Further, Fawcett, et al. (2007) and Kembro, et al. (2014) identified: cost and complexity of implementing advanced systems and existing systems incompatibility as barriers to better information sharing. Furthermore, Fawcett, et al. (2007) adds; different levels of connectivity exist up and down the chain and “Managers do not understand the willingness dimension of information sharing!” as two more barriers. Kembro, et al. (2014) on the other hand adds; confidentiality of shared information and the risk of partners reaping all the benefits and the fear of becoming overly dependent on partners who receive the information as factors that may have negative effect on information sharing in supply chains.

### 2.2.5 Supply Chain Risk

Supply Chain risk has varying definitions throughout all literature, some of the authors have chosen to define it conceptually, other have defined it quantitatively. For example, Christopher and Peck (2004) have chosen to define Supply chain risk as an exposure to shocks from both within and outside of the network, while Manuj & Mentzer (2008) have chosen to quantify Supply Chain risk and define it as the probability of a risk occurring as well as the impact of that risk on the performance of the supply chain.

The authors, Bahroun & Harbi (2015), conducted a review of over 20 research papers about Supply Chain risk and identified four main categories for supply chain risk. The first one focuses on external risk, while the remaining three, focus on internal risk.

The **first risk** is the environmental (or external) risk. The definition for environment differs from economic, social, political, legal, operational and natural. The authors also identified what the sources for the risks were. For environmental risk, they were:

- Crisis and natural disaster
- Terrorist attack
- Labor related cost
- Currency
- Security
- Social environment
- Political environment
- Legal environment
- Strikes and economic disruptions

The **second risk** was identified as supply risk. Supply risk mainly depends on reliability of suppliers and time delay. The product simply doesn’t match three measurement parameters in supply chain; time, quality or quantity. The sources were identified as:
- Failure of Supplier
- Inbound product quality
- Supplier opportunism
- Transit time variability
- Rise in prices
- Lead time variability
- Yield variability
- Failure of logistics service provider
- Product quality

The third risk was identified as demand risk and it is the risk of the product not being in demand. This risk is product oriented and is between the company and the customer. It also includes risks as customer dissatisfaction, overstock and obsolescence. The sources were identified as:

- Demand variability
- Forecast errors
- Competitor moves
- Customer dissatisfaction
- Changing consumer tastes
- Failure of logistics service provider
- Product quality

The fourth and last risk was identified as the process risk. The process risk exists in all internal operational activities such as production, storage and warehousing, or distribution risk. It affects the internal capabilities of a company’s pre-set goals and delivery of products and services. The identified sources were:

- Asset and tools ownership
- Inventory ownership
- Product quality and safety
- Managerial risks
- Loss of production
- Shortage of employees
- Yield variability

Furthermore, the same authors have identified that there are two generic strategies to cope with supply chain risk, proactive management strategy and reactive strategy management. As the names of the strategies might reveal, the former strategy focuses on identifying and preventing supply chain risks before it damages the supply chain. This is mainly done by minimizing occurrence of critical scenarios by adding robustness to the supply chain. The latter, reactive strategy management, attempts to limit the impact of the consequence of risks that are hard to foresee. This requires quick and flexible reactions and an awareness of what options are available for different problems.

Lately as technology has evolved so rapidly, more and more application areas are identified. An article written by Alicke, et al., from McKinsey discusses a term called Supply Chain 4.0 (Alicke, et al., 2016), which is a summary of the change currently occurring in Supply Chain Logistics through digital technologies. Following is a closer look at the trendiest technologies,
especially Blockchain. (Pettey, 2018) Robotic Process Automation will not be documented as this report focuses on information sharing.

2.3 Blockchain
The technology Blockchain was first created back in 2008 when Satoshi Nakamoto, an anonymous person or group, announced the launch of the most famous cryptocurrency Bitcoin through a white paper (Nakamoto, 2008). The purpose of Bitcoin was to allow to trade true value on an open source decentralized ledger, without the need of a third party. The technology allowing this to happen safely is Blockchain, by recording transactions – the shared ledger – and allowing to track the movement of the assets. The authors, Don & Alex Tapscott of the book Blockchain Revolution (2016) describe Blockchain Technology as follows: “The blockchain is an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value.” This is made possible due to the three technologies that Blockchain are built from:

1. Public Key Cryptography
2. P2P (Peer-to-Peer) Network
3. Program (The blockchain protocol)

The purpose of these three come from creating a digital trust. A Private Key Cryptography provides a powerful tool that fulfils authentication requirements while not demanding to much personal information, eliminating exposure for hackers. However, authentication is not sufficient to make a trade, you also need authorization. Authorization is the process of validating that the involved parties have enough money, broadcast the correct transaction type, etc. This authorization needs a starting point in a P2P Network. Finally, these transactions must occur on a secure and recordkeeping network, the Blockchain protocol. (Bauerle, 2017)

2.3.1 Basics of Blockchain
The technology of blockchain has often been referred to as a “digital ledger”. This is because of the functionality of blockchain, where information is constantly reconciled into a database that is updated and stored on multiple locations. Since it is a decentralised storing system, it is much harder to hack. Whenever a new transaction occurs, a block is created. This open transaction must now be validated, and its “puzzle” must be solved in order to join the network. In Bitcoin, the entity solving these “puzzles” are called miners. However, these validation processes vary depending on what consensus system is used. (Dughi, 2018) Blockchains can be divided into three different groups, public, where there is a permissionless access for everyone, permissioned, that only parties given permission are able to access the content of the blockchain and a hybrid, with a mix of both. Permissioned blockchains are also referred to as private, permissionless as public and a mix of both as consorted blockchains.

Public Blockchain
A public blockchain not only allows you to trade without a third party, since it is a decentralised open source system, any changes to the Blockchain are updated to all the parties involved in the Blockchain, making it an easily trackable system. Furthermore, all transactions are timestamped and intertwined into the decentralized digital ledger, creating blocks in an “immutable” chain, hence its name. The “immutable” part is created through the chain, where all blocks have a hash identifying the previous block, as well as the following. The first block is called the genesis block and is the start of the chain. Since all blocks are unique and can’t be combined freely, it is not feasible to manipulate the data stored on a blockchain. The reason it
is not feasible but not impossible, is since there is a possibility, but in order to manipulate the hashes, you have to identify the encrypted connections by the brute-force method, meaning that you have to pick up a random input, hash it and then compare it to the target. This process must be repeated until you find a match, which demands computational power generating costs far higher than the reward. The encryption that most of the blockchains and cryptocurrencies use, is called SHA-256 and is used in many financial institutes. Although there are some mathematical weaknesses with the SHA-256 encryption, it is considered to be strong enough for a foreseeable future. (Grimes, 2017)

![Diagram of hash technology](image)

Figure 4: The figure illustrates the chain building in hash-technology as each block is dependant of the block in front of it as well as the one behind it.
(Source: Own illustration based on (Thesamithanik, 2018))

According to the authors Shaikh & Lashari, (2017) the strengths and weaknesses of a public blockchain can be summarised as:

- Slow and less efficient
- Built-in virtual currency
- Simple and inflexible
- Have high community support
- Forked heavily
- Complete and tested

**Private Blockchain**

To share information transparently to a closed group of participants, recent blockchain systems have been developed to create a permissioned distributed ledger. In these private blockchains, the nodes have to be authenticated. Unlike the public permissionless blockchains, the nodes in private blockchains are known and don’t demand the same identification to remain secure and solutions can be more efficient and deterministic. (Dinh, et al., 2017)

Shaikh & Lashari (2017) summarises the characteristics of a private blockchain as:

- Fast and highly efficient
- Highly secured
- Easy to upgrade
- Designed for private network
• Have high enterprise support
• Lacks critical enterprise features

**Consortium Blockchain**
The concept of a hybrid blockchain where you mix both the private and public blockchain. In this type of blockchain, the blockchain can be tweaked to create restricted access for specific data. These hybrid solutions can be implemented between companies while still maintaining the intellectual property of the information stored. Consorted blockchains are popular to use in multi-organisations purposes since it combines the possibilities of a public and private blockchain.

Shaikh & Lashari (2017) summarise the characteristics of a consorted blockchain as:

• Fast and efficient
• Highly secured
• Easy to upgrade
• Simple and flexible
• Have high community support
• Have high enterprise support

### 2.3.2 Key characteristics of Blockchain
The blockchain is often regarded to as an economical and efficient system because of the elimination of third parties having to authorise the transactions. Furthermore, it is considered more secure against hackers based on the consensus models validating the exchanges. According to Gupta (2018), blockchain network has the following key characteristics:

• Consensus
• Provenance
• Immutability
• Finality

However, key characteristics differ and the authors Zheng, et al. (2017) divide the key characteristics of blockchain to:

• Decentralisation
• Persistency
• Anonymity
• Auditability

All of these key characteristics are presented below.

**Consensus**
For a transaction to be valid, all parties involved must agree on the transaction been done correctly. As discussed earlier, different blockchains use different validation systems (consensus mechanisms). According to Gupta (2018) consensus mechanisms include the following:

• *Proof of stake* – Validating transactions takes a certain percentage of the networks total value, rendering attacks against the system expensive and difficult to execute.
- *Multi-signature* – A majority of validators must agree on the legitimacy of the transaction.
- *Practical Byzantine Fault Tolerance (PBFT)* – PBFT is an algorithm created to settle disputes among computing nodes.

The author Gupta (2018) only includes consensus mechanisms that according to himself are applicable on businesses. Therefore, the most known validation system *Proof of Work*, is excluded, as it is considered costly and inefficient for businesses. In this study, more consensus mechanisms will be presented, partially to increase the understanding of the technology for the reader, but also to minimize fault in advising what consensus mechanism are suitable for businesses.

Another interesting addition to validating systems is *Smart Contracts*. A smart contract is a set of rules set out by the involved parties in order to govern a business transaction and is executed automatically if the set of rules are obtained.

More on consensus mechanisms in section 2.3.4, and Smart Contracts in section 2.3.5.

*Provenance*
The participants inside the blockchain must have access to knowledge of where the assets came from and how its ownership has changed over time. (Gupta, 2018)

*Immutability*
In an immutable system, as blockchain is described, the manipulation of an approved transaction can only be reversed through a new transaction making both of the transactions visible. As mentioned before the system might not be immutable per say, however, hackers are discouraged as the cost surpasses the reward many times about. (Gupta, 2018)

*Finality*
There is only one version of the open source ledger. If you want to go and see the true ownership of an asset, that ledger is the sole source. This creates a unity in information comprehension and transparent partnerships in business situations. (Gupta, 2018)

*Decentralisation*
In traditional transaction systems, a third party needs to validate the transactions, and take a hefty fee and time to complete this service. In blockchain technology, a transaction can be conducted peer-to-peer without any third party validating the transactions. Therefore, there is potential to minimise cost and time waste. (Zheng, et al., 2017)

*Persistency*
Since all transactions are wired into the network through blocks and verified through validating systems, it is almost impossible to manipulate and change after the transaction has been made. Any attempt for falsification will be discovered easily as it is shared to plenty of nodes of the system. (Zheng, et al., 2017)

*Anonymity*
By using private key cryptography each individual receives a unique address and will also generate many addresses to avoid identity exposure. Furthermore, since it is a decentralised system, there is no entity storing your identity details. This mechanism preserves lot of privacy,
however as mentioned earlier, the basic principle of blockchain is traceability and the ability to see the earlier and current ownership. (Zheng, et al., 2017)

**Auditability**
Each transaction is timestamped and put into a chain, making it possible to trace all earlier ownerships and transactions. This improves the traceability and transparency of the information storage. (Zheng, et al., 2017)

2.3.3 Blockchain builds Trust
An important aspect as presented earlier in information sharing is willingness, which is built around trust. Gupta, (2018) explains that since blockchain transactions cannot be tampered with without any party noticing, any misbehaviour in a collaboration is apparent. This means that with blockchain it is not a question of whether you can trust someone, you simply do not have to have trust involved when operating on a blockchain network. The author further explains that the trustless system blockchain is built through five attributes:

- *Distributed and sustainable*
- *Secure, private and indelible*
- *Transparent and auditable*
- *Consensus-based and transactional*
- *Orchestrated and flexible*

**Distributed and Sustainable**
All information is stored on an open source ledger that is near to real time updated and selectively replicated amongst participants in the blockchain. No single entity has the power to control the continued existence of the blockchain as there is no single owner of the blockchain.

**Secure, Private and Indelible**
Through cryptography and permissions, you can ensure unauthorized entities are denied access to the network. Furthermore, confidentiality can be assured through cryptographic- and/or data partitioning-techniques. When conditions are agreed upon in a blockchain and a transaction is completed, it cannot be reversed. The only option is to create a new transaction.

**Transparent and Auditable**
Since the transactions cannot be tampered with and are accessible for all parties involved, no third parties are needed to verify transactions as well as ownership. Furthermore, since all transactions are time-stamped it increases the traceability.

**Consensus based and Transactional**
As mentioned before, consensus is the agreement between all participants in regard to transactions or value exchange. Consensus is a validating algorithm and can vary depending on the purpose and involved parties. Therefore, a challenge for businesses is to conclude which consensus-technology is viable and suiting for their blockchain.

**Orchestrated and Flexible**
Business rules change over time and evolve constantly. Since these can be built into the platform, the blockchain network can evolve and over time mature in correlation with the market evolving.
2.3.4 Consensus Mechanisms

Consensus mechanisms from a blockchain perspective is the ability to create an agreement of a transaction between all parties involved without needing the help of a third overseeing party. As discussed earlier, consensus mechanisms vary from different blockchains. Depending on if you have a public- or private/consortium blockchain, different consensus mechanisms are viable. According to the authors, consensus mechanisms can be divided into two groups, Lottery-Based Consensus mechanisms and Voting Based Consensus mechanisms. (He, et al., 2018)

The consensus mechanism is the cornerstone of blockchain and although not all of the examples below are applicable within Supply Chain Logistics, in order to increase the understanding of blockchain and the possibilities, different kinds of consensus mechanisms will be described briefly.

Lottery-Based Consensus Mechanisms

Lottery-based consensus mechanisms are most known for their utilisation in public blockchains. On a permissionless network, security is a key factor. These consensus mechanisms can therefore not hold any favourites to maintain the decentralisation on the open-source ledger. These mechanisms therefore randomise their validators; therefore, you have to be “lucky” to become a validator. (He, et al., 2018). Although there are many different lottery-based consensus mechanisms, explanations will only be made on the arguably most popular ones, Proof of Work and Proof of Stake.

Proof of Work

Proof of work (PoW) is the consensus mechanism used in Bitcoin (Nakamoto, 2008). Using this consensus mechanism, a prover shows a verifier that a certain task has been resolved with a certain amount of computational work in a specific period. In the case of Bitcoin, the provers are called miners and are in charge of resolving algorithms. This computational work consists of computing a hash of block. The work is quite demanding on purpose in order to create a validity to the transaction, security, anti-spam and to ensure double-spend doesn’t occur. (He, et al., 2018)

A big concern with the PoW consensus mechanism is the incredible computational power needed to validate the transactions. As Bitcoin soared in popularity, more and more scalability issues were revealed. One of these issues was the limitations in the amount of transactions possible to complete due to the block size. Another one is the limitation of the consensus mechanism, since new transactions and information needs to be updated and validated of all the nodes on the blockchain. (Chauhan, et al., 2018)

Proof of Stake

Proof of Stake (PoS) is a consensus mechanism used to validate blocks. The mechanism was first introduced back in 2011 and has since then been used in cryptocurrencies to approve transactions. The main advantages with PoS is security and energy efficiency. (Lisk, 2018)

Unlike a PoW system, the validator in a PoS system is chosen by a randomized system that takes into consideration the amount of assets in possession as well as how long the assets have been in possession. (He, et al., 2018) This randomized system prevents centralisation, as a problem in PoW is that the richest often get to create the next block having superior computing power through vaster resources and therefore, they collect all rewards from the system,
increasing their wealth even further. Furthermore, in PoS, the validation does not come from computational power, but is dependent on the amount of assets in possession in order to motivate honesty in the system. The reward from validating is then kept locked up in the system to prevent dishonest approval of faulty transactions. (Lisk, 2018) The validators of the system that are “randomly” selected are called Minters. The Minters are forced to deposit some of its assets in the network, a collateral to incentivise honesty. (Adjoint, 2017)

A major concern with PoS is the 51% attack. Just as it sounds, the attack can occur if an individual or group obtain 51% of the assets on the network. This is however very unlikely. First of all, acquiring that much assets as a single buyer would create a counter-reaction from the network. This counter-reaction could be people leaving the network or others ramping up the prices to not allow a majority asset party. Furthermore, an attack on a network is not lucrative, as the value of the asset would decrease rapidly. Also, worth mentioning is that the concern of the 51% attack in PoW is far greater than in PoS, as a lot of miners pool their resources together, creating big mining groups. (Lisk, 2018)

**Voting-based Consensus Mechanisms**

These consensus mechanisms are usually validated through several rounds of voting and have shown big issues with scalability. They are therefore often used for private and consorted blockchains.

**Practical Byzantine Fault Tolerance**

The Practical Byzantine Fault Tolerance (PBFT) consensus mechanism is an algorithm that is able to endure Byzantine Faults. A Byzantine fault is any fault that has different symptoms depending on the observer. Under PBFT, in each round, the person responsible for ordering the transaction is selected as a primary. The rounds consist of determining new blocks. For PBFT to work, the system assumes that the errors of the system never surpass (N-1)/3 faults, where N is the number of total nodes. In simple terms, a third of all nodes have to act “correctly” for the system to work.

Unlike PoW, in PBFT, consensus can be reached with low network communication and low network latency. According to Sukhwani et al., (2017) PBFT is only applicable on permissioned blockchains where all the nodes are whitelisted and known and contractually obliged to behave “correctly”. Castro & Liskov (1999) first introduced the PBFT algorithm in 1999 in their report called Practical Byzantine Fault Tolerance. In the report, the algorithm is divided into four steps.

1. A client sends a request to invoke a service operation to the primary (First node in a view, view being a succession of configurations).
2. The primary multicasts the request to the backups (the other nodes in a view).
3. Nodes execute the request and send a reply to the client.
4. The client waits for f + 1 replies, where f is the maximum number of nodes that are allowed to be faulty, from different nodes with the same result; this is the result of the operation.

Furthermore, the creators of this algorithm have set out two requirements. The first one is the demand set out on replicas/nodes to be deterministic. The definition of deterministic nodes is that the executions of operations in a given state and set of arguments always produce the same result. The second one is that they all start in the same state. (Castro & Liskov, 1999)
Proof of Authority

Proof-of-Authority (PoA) is a new tweak of the PBFT algorithm, which has soared in popularity. PoA is quite similar to PBFT in the sense of validation occurring in rounds where a mining leader is elected for each round. (De Angelis, et al., 2017) This means that the consensus mechanism is not dependant on solving complex mathematical problems, but instead specific authorities are given permission to create blocks and secure the Blockchain. (He, et al., 2018)

In comparison to PBFT, PoA requires less message interactions and therefore provides a superior performance. This is however, something that has not been tested on a larger scale, especially in regard to availability and consistency. In comparison to PoW, in a permissioned Blockchain, PoA is more secure, less computationally intensive, more predictable and provides lower transaction latency. Although Proof of Authority has been regarded as a promising consensus mechanism for permissioned Blockchain, recent qualitative analysis conducted shows the lack of consistency. (De Angelis, et al., 2017)

2.3.5 Smart Contracts

Smart contracts are generally described as computer protocols that through predefined rules facilitate, execute and enforce a contract set up between two or more parties. This computer protocol removes the need for contractual clauses. Although the smart contract often is regarded as a state of the art technology, the idea was introduced back in 1996 by a computer scientist, named Nick Szabo. Mr Szabo predicted that the digital revolution would have a great impact on the way contracts are made. Smart Contracts on the blockchain allows the rules to be encoded in a program that is replicated to all blocks in the blockchain protocol. As the content of contracts could contain sensitive information, it is encrypted through a public key or a commitment scheme. The contract verification is then validated and enabled through consensus mechanisms. Finally, the results are stored on the blockchain. (Covaci, et al., 2018)

2.3.6 Blockchain Protocol

A blockchain protocol constructs a distributed ledger (Halpern & Pass, 2017). The protocol is what decides the inter-node communication in the peer-to-peer network of the distributed ledger. This also includes the consensus mechanisms of the blockchain and whether it’s permissioned or permissionless. (Raval, 2016) It is important to understand that the blockchain protocol differs for blockchains with different purposes. Therefore, a representation of three different blockchains will be made. The different protocols have been chosen based on popularity as well as how much they differ. Each protocol will be given a short introduction followed by a brief clarification on the following technical differences; consensus mechanisms and accessibility.
Bitcoin
Bitcoin was first introduced back in 2008 by an anonymous group/person in a whitepaper, where the author suggested that it had a solution for the independency from financial institutions for everyone. The revolutionary part of Bitcoin was the distributed ledger where peer-to-peer transactions of true value could be made without the need for financial institutes. As mentioned before, Bitcoin uses the Proof-of-Work consensus mechanism and is accessible to anyone. The purpose of Bitcoin, initially, was to revolutionise the financial sector and create a Protocol where everyone can trade with everyone, securely, transparently and efficiently, without the need of a third party taking a piece of the profit. (Nakamoto, 2008) As Bitcoin soared in popularity, some issues with scalability were presented.

Ethereum
Although the Ethereum protocol is built on the same technology, is accessible to everyone, and uses the same consensus mechanism, its intended purpose is something completely different. The young Ukrainian Vitalik Buterin created Ethereum in order to provide a protocol for companies/individuals to create decentralised applications (Dapps) easily. The applications on the Ethereum protocol are divided into three groups, financial, partially financial and non-financial which creates a wide utility area for the protocol. It was also in the Ethereum protocol that smart contracts were introduced and showcased a new extension to the blockchain technology. (Ray, 2014)

Hyperledger
Hyperledger launched back in 2016 with a governance of 30 founding corporations. Although the Hyperledger is a collective name for different protocols, the main differentiating factor is that this protocol was created by corporate companies that saw the potential of blockchain technology and created a platform for companies to build their own blockchains and adapt them to fit their businesses. Although this goes against the primary idea of having a completely decentralised system on a distributed ledger, more and more companies are implementing blockchain solutions to gain the unique characteristics that blockchain offers. (Hyperledger, 2018)

2.3.7 Examples of companies using Blockchain and how
Blockchain technology has been successfully implemented in a few cases by market-leading innovative companies. The areas, where these Blockchain solutions have been implemented,
vary widely as does the utilization areas of Blockchain, showcasing the versatility of Blockchain.

**Walmart**

Walmart is one of the biggest food retailers in the world. Together with the leading tech-company IBM, they created a food supply Blockchain in order to track information regarding different merchandise. Big companies as Walmart, have very long and complex supply chains, creating a problem to track down the origin of certain merchandise. Before using the Blockchain solution, it took 7 days on average to trace the source of the food. After implementing the IBM Hyperledger Food Trust solution, which is an adapted Blockchain solution especially for this use case, the tracking time was reduced to 2.2 seconds. Which drastically reduced the likelihood of infected food reaching the store. A spokesperson for Walmart also expressed the importance of having a transparent supply chain showing their consumers the journey and origin of their food. (Miller, 2018)

**Siemens**

Siemens has invested in a smaller company called LO3. LO3 has created a blockchain solution where neighbours can share and sell their solar power on a blockchain powered network. The plan behind it is for people who have solar panels who produce more electricity than they consume on sunny days, to sell this energy in real-time without the need of a third part to verify the transaction. This solution was possible thanks to three things, first, every energy transaction was timestamped and documented. Second, Siemens offered a microgrid-specific technical solution. Third, Siemens made it possible through financing. (Breuer, 2018)

**Maersk**

Maersk is the world’s largest shipping company. Back in March 2017 they finalised their first test of Blockchain technology which aimed to help them manage their cargo. The parties involved in the test were Maersk, the Dutch customs and the Homeland Security of the US. In the test, the involved companies were successfully able to access data remotely about the cargo, suggesting that Blockchain technology could be a benefiting factor in securing international shipping. (Krauth, 2018)

**American Express**

The financial services giant American Express has recently started integrating blockchain into a rewards program through the partnership of a digital retailer called Boxed. American Express card holders will be able to create custom *Membership programs* on the Hyperledger (blockchain protocol). It will serve a purpose of allowing members to earn five times the normal number of points on specific products. On the back-end, American Express will also create a consorted blockchain solution creating the possibility for each merchant to facilitate information transfer. Merchants can through this create smart contracts which will allow for reward program offers being automatically fulfilled. As a result of this, merchants will be able to control the structure of their membership reward as well as what offers they make. American Express also believes that it can set up merchants much faster with the current system, resulting in a faster onboarding of new merchants. (De, 2018)

**Pfizer**

The German pharmaceutical giant Pfizer has formed a partnership with Genentech to create the MediLedger Project which uses blockchain technology to track drugs across the supply chain. The blockchain technology provides a decentralised platform where ownership lies
with all stakeholders rather than with a single centralised authority. This means drug manufacturers, distributors, wholesalers, retailers and hospitals all have to play their part in recording drug deliveries. This allows to keep track in real time of all legal changes of ownership throughout the journey of all products. Furthermore, since all steps are recorded and placed on a blockchain protocol, it allows to prove the provenance of the medication, erasing any doubt of the validity of the medication. (Ali, 2018)

2.4 Digital technologies

There are many digital trends used in logistics and supply chains with many technologies related to the physical- and information flow, with technologies related to the physical flow being disregarded in this thesis. To give a basic understanding of some existing technologies and current digital trends that is used to handle and share information, the following questions will be answered briefly concerning the technologies. What is it? Why is it important/what are its benefits?

2.4.1 Information and Communication Technology – ICT

Information and Communication Technology is generally accepted to mean all devices, networking components, applications and systems that combined allow people and organizations to interact in the digital world. (Rouse & Pratt, 2017)

The amount of ICT components is great and continues to grow, but it is in the application of these components the real potential, power and risk can be found (Rouse & Pratt, 2017). The following digital technologies can by the ICT definition be grouped as ICT components.

2.4.2 Automatic Identification and Data Capture – AIDC

AIDC comprises a set of technologies that capture or collect data in an autonomous way, without the need for manual input. The central types of AIDC systems are Radio Frequency Identification (RFID), Smart Card, Biometrics, Barcode systems and Optical Character Recognition (OCR). (Rahman, et al., 2011; Rouse, 2010) AIDC technologies can reduce or even eliminate errors in collection of data and manual entry of data. Industries where the technologies have been applied successfully contain retail, manufacturing and logistics. (Hodgson, et al., 2010)

2.4.3 Cyber-Physical Systems – CPS

There is a wide variety in definitions of what Cyber-Physical Systems actually are. To be able to enable a common scientific discussion Klötzer & Pflaum (2015) compared available scientific literature and derived two definitions of CPS, one in a broad sense and one in a narrow sense. These definitions are:

CPS in a broader perspective: “‘Cyber-Physical Systems’ are (among themselves) interconnected and networked embedded systems. They monitor, govern and control the physical world via sensors and integrate the obtained data into the virtual (informational) world." (Klötzer & Pflaum, 2015)

CPS in a narrower perspective: “‘Cyber-Physical Systems (CPS)’ are distributed, (among themselves) interconnected, networked embedded systems using real-time communication. They monitor the processes of the physical world via sensors, govern and control them through actors and integrate the obtained data into the virtual (informational) world. CPS also distinguish themselves by a high level of adaptability and by the accomplishment of mastering complex data structures." (Klötzer & Pflaum, 2015)
Rajkumar, et al. (2010) explains that CPS can be considered to be a union of embedded systems, real-time systems, distributed sensor systems and controls while Klötzer & Pflaum (2015) presents Real-Time Locating Systems (RTLS), RFID, Near Field Communication (NFC), Wireless Sensor Networks (WSN) Telematic Modules and Embedded Systems to be enabling technologies for CPS-realization. CPS must operate in real-time, efficiently, safely, securely and dependably, and the technology will transform the way humans’ control and interact with the physical world. (Rajkumar, et al., 2010)

The CPS can gather a great amount of data about their digital processes and their real environment, automatically, which eliminates the need for manual data gathering and transfer to the storage system and the risks of errors in this process. With the continuous development within the area, more and better data can be recorded which allows for detailed monitoring of the environment. (Kagermann, 2015)

2.4.4 Internet of Things – IoT
Physical objects are being connected to the internet and are transformed from being traditional objects into being smart. The IoT enables these smart objects to see, hear, think, perform tasks, and interact with other objects, share information, and coordinate decisions. The IoT makes this possible by using enabling technologies such as ubiquitous and pervasive computing, embedded devices, communication technologies, sensor networks, internet protocols and applications. (Al-Fuqaha, et al., 2015)

Internet of Things is one of the most hyped up concepts within the IT world due to the possibility it brings of a global infrastructure of networked physical objects. It enables connectivity at all times for anything and not just for people. (Madakam, et al., 2015) It allows for machine-to-machine (M2M), person-to-machine (P2M) and person-to-person (P2P) communication and traffic flows, and by 2022 it is expected that M2M traffic flow will make up 45 % of the total internet traffic. (Al-Fuqaha, et al., 2015) The ability to interconnect products and supply chain members in the physical world with information in the virtual world is the reason IoT is seen as the solution for many industries. (Tu, 2018) With the information IoT can provide it is possible to shorten cycles of logistics processes and optimize their cost and thereby improve customer service. (Witkowski, 2017)

With IoT real time supervision of the transportation process of goods, packages and letters are made possible, and customers can be informed of potential delays ahead of complications. Tracking and tracing becomes faster, more precise, more predictable and safer. In terms of warehousing, intelligent shelving and pallets will carry modern inventory management forward. The monitoring of the condition of things in combination with analytics make it possible to predict failure and automatically plan moves to improve the supply chain. (Witkowski, 2017)

2.4.5 Big Data & Big Data Analytics
The most popular and adopted attributes by which to describe Big Data was casted by Douglas Laney in 2001. These are called Gartner’s interpretation or 3Vs, which are:

1. “Volume, which means the incoming data stream and cumulative volume of data
2. Velocity, which represents the pace of data used to support interaction and generated by interactions

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3. Variety, which signifies the variety of incompatible and inconsistent data formats and data structures” (Wu, et al., 2016)

Since then there has been many additions in dimensions of Big Data. Forrester added Value to create a 4V definition, as an aim to isolate the most important information for us (Witkowski, 2017). IBM on the other hand added Veracity, which implies uncertainty of data to make their own 4V definition. Yuri Demchenko added Value along the IBM definition. To maximize business value, Microsoft extended the original definition by three Vs. Veracity, which focus on trustworthiness of data sources. Variability, which in comparison to Variety refers to complexity and numbers of variables in data sets. Visibility, which states that a full picture of data is needed for an informative decision. (Wu, et al., 2016)

Big data is an important asset to businesses due to the possibility it creates to extract knowledge through analytics, and thereby gain a competitive advantage (Al-Fuqaha, et al., 2015). Witkowski (2017) further explains that Big Data makes more advanced levels of analyses of data possible, compared to traditional tools. Big Data ensures that data that has been captured from mutually incompatible systems, databases, websites can be processed and combined to give a clear image of the situation related to a certain company or person. (Witkowski, 2017)

2.4.6 Artificial Intelligence – AI

The founding fathers Marvin Minsky and John McCarthy defined AI as any task performed by a program or machine that requires intelligence. The “intelligence” of AI can be connected to human intelligence mostly in planning, learning, reasoning, problem solving and creativity. (Dinh & Thai, 2018) Although AI seems to be a new technology, way back in the 1950’s, Alan Turing wrote a paper with an opening statement: “Can machines think?”. In the same paper, the famous Turing test was introduced, which in summary is a test to see if a suspicious human judge can identify whether it is communicating with a human or an AI. (Muggleton, 2014) Artificial Intelligence is the technology which learns through iterative processes to serve its pre-set purpose. However, this is a very simple explanation, and the problem with AI is that it is so complex, that it is unreasonable to hope for a short and summarised explanation of the decision-making process of an AI. (Monroe, 2018)

According to the authors Dinh & Thai (2018) the recent resurgence of AI has been driven by the breakthroughs within the fields of machine learning and deep learning. Furthermore, the authors also consider that it might be because of the explosion in available data, making machine learning programmes more effective by providing more data. AI has opened the doors for many things that were thought of impossible or at least further into the future, such as self-driving cars, delivery robots etc. However, it has also raised many issues, mostly moral. One big concern has been the monopolization of the technology. As AI needs big amount of data, some argue that only big companies like Google, Microsoft and Amazon get to utilise the technology. This has created a concern among individuals about the use of their private data to improve algorithms of worldwide enterprises. (Dinh & Thai, 2018)

According to the authors of Future of AI (2018) the integration between Blockchain and AI is inevitable, as they complement each other in aspects such as efficiency, scalability, as well as trustworthiness and privacy.
2.4.7 Cloud Computing

The authors Caldarelli, et al. (2017) argues that there is a variety of definitions of cloud computing in literature. However, most of them derive from the definition below, provided by the US National Institute of Standards and Technology (NIST).

“Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models.” (Mell & Grance, 2011)

According to (Carroll, et al., 2011) a level of consensus is emerging over the characteristic of cloud computing, defined by Mell & Grance (2011). These are: on-demand self-service which is automatic provisioning of computing capabilities, broad network access meaning capabilities are available over a networked infrastructure, resource pooling refers to a multi-tenant model being used to pool resources together to serve multiple customers, rapid elasticity means being able to quickly scale up or down as required by rapid and elastic provisioning of capabilities, and measured service referring to automatic control and optimization of resources by using a pay-per-use model.

Service models: Infrastructure as a Service (IaaS), Platform as a service (PaaS), and Software as a Service (SaaS). Carroll, et al. (2011) easily explain the service models and cloud computing as IaaS being hardware, PaaS being technology tools, and SaaS being software, that are available on demand as opposed to purchased hardware, or licensed tools or software.

Deployment models: Private cloud, Community cloud, Public cloud, and Hybrid cloud. The deployment models refer to how the infrastructure of the cloud is provisioned. A Private cloud may be used for exclusive use by an organization with multiple consumers, a Community cloud for exclusive use by organizations with shared interests, a Public cloud for use by the general public, and a Hybrid cloud is a composition of two or more of the aforementioned cloud infrastructures.
3 Precision of task

In the following chapter, the studied system is presented, followed by a breakdown of the purpose of the thesis, which lead into a more descriptive presentation of the research questions.

3.1 Studied system

The studied system encompasses the information sharing aspect of Supply Chain Logistics. More thoroughly described, the forward and backward sharing of information between suppliers and customers in the studied supply chain, excluding the internal system of the two and mainly focusing on the information sharing in-between. Concerning blockchain the main focus will be on the potential for the focal company.

The studied system with system boundaries is illustrated below in figure 5 and figure 6.

![Figure 6: Illustration of the studied system. Although Suppliers and Customers are excluded, the information sharing in-between is included. (Source: own illustration.)](image)

![Figure 7: Illustration of the studied system with focus on information sharing with a Blockchain application. (Source: own illustration.)](image)

3.2 Breakdown of purpose

As outlined in chapter 1.2 “The purpose of this thesis is to explore the potential of blockchain technology in digitalizing Supply Chain Logistics.”.

In terms of exploring the potential of blockchain, the first necessary part is to understand what blockchain is in a structured and thorough way. This led to the first research question to form as: “What is blockchain?”.

Blockchain has proven to have many different application areas and a versatile adaption in its technology. This has created different protocols of blockchain and thus made it a greater challenge for companies to comprehend the implementation. To clarify what steps should be made for supply chain companies looking to implement a blockchain protocol, the second research question was formed as: “How can companies implement a blockchain protocol?”
The digitalization of Supply Chain Logistics, and on an underlying level, the information sharing in a supply chain, is inevitable. Therefore, the potential of blockchain for information sharing in a supply chain will be investigated, in order for companies to understand the potential benefits of blockchain. Since a blockchain can be formed differently, the challenge lies within identifying what value a blockchain protocol can bring in comparison to current organizational configurations. Therefore, the final research question was formed as: “How can companies benefit from using blockchain?”

3.3 Breakdown of research questions

The research questions have been broken down into sub-questions to become more specific towards the explored areas. As well as to build a base to be able to answer the research questions properly.

3.3.1 What is blockchain?

To gain an understanding of what blockchain is the question is divided into three parts, the first is the elemental understanding of key term about blockchain, the second is slightly more technical with the underlying technology, and the third is to investigate current implementations of the technology.

An important factor in understanding blockchain is to understand what it is, but equally important is to understand what it is not. A way to achieve this is to investigate connections to other technologies if there are any, how the technologies group together, and their utilization areas. This leads to the first sub-question being: How does Blockchain relate to other digital technologies?

Barratt & Oke (2007) explain that supply chains can be made more efficient through information sharing by providing visibility. Bartlett, et al., (2007) found that with transparency as a measurement for visibility, the overall performance of a supply chain could be improved by exchange of the correct information. They also found that uncertainty could be reduced and coordination improved by the use of external information, which might be the reason externally integrated companies often outperform non-integrated companies.

Information sharing is a combination of connectivity and willingness, where Fawcett, et al., (2007) describes connectivity as to what extent companies can gather, analyse, and share information, while willingness is whether companies will share decision-making information. Willingness is about building trust and nurture relationships between the involved companies (Williamson, 1975). In relationship management, the purpose of connectivity is to create relationships between firms at many levels while the purpose for transactions is to create flow between functions in the supply chain (Lambert, et al., 2005). This leads to the second sub-question: How does Blockchain relate to information sharing?

3.3.2 How can companies implement a blockchain protocol?

There are many ways of setting up a blockchain due to the variety of technologies that make up a blockchain. In the current state, the few companies that have implemented blockchain have outsourced the construction of their blockchains to third parties that have adapted blockchain protocols with pre-set consensus mechanisms such as Ethereum, Hyperledger Fabric from IBM, Hyperledger Sawtooth Lake from Intel, to suit their own business and purpose. (Suprunov, 2018)
Considering how companies experience dissimilar challenges with information sharing, it is important for companies to realize that there are many customization options with blockchain. Forming a blockchain from a technical aspect might be complex and risky as a blockchain is only truly immutable if it is not built on a flawed basis without wormholes for people with malicious intent. (Suprunov, 2018)

Within sharing of information in a supply chain, companies face the challenge of identifying how they want their information to be shared on their permissioned blockchain. Accordingly, since the functions of the blockchain are decided when adapting the protocol, the sub-question will be: *What should companies consider before and during implementing a blockchain protocol?*

### 3.3.3 How can companies benefit from using blockchain?

To make the transition from current IT-systems to using blockchain companies need to see the benefits it will bring compared to what is offered today. Since blockchain is a new technology, it is hard to argue that it will completely substitute other IT-systems. Instead, depending on what information parties want to share in a supply chain, it is important to investigate how blockchain can offer new functions of sharing information or improvement to the current ones. The first sub-question was therefore formed as: *How does blockchain compare to current IT-systems in information sharing?*

Furthermore, it is important to understand of how various information should be handled differently depending on which aspects of connectivity and willingness are considered most important. There might be restrictions on which data is appropriate to share or store on a blockchain, or that current IT-systems still work better for certain types of information. Therefore, it would be interesting to explore how companies could utilize both blockchain and IT-systems in their supply chains and investigate which data blockchain should be used for. This led the second sub-question to be formed as: *What kind of data/information should blockchain be used for based on certain aspects of information sharing?*

### 3.3.4 Summary of research questions

The research and sub-questions summarized:

1. **What is blockchain?**
   1. *How does blockchain relate to other digital technologies?*
   2. *How does blockchain relate to information sharing?*

2. How can companies implement a blockchain protocol?
   1. *What should companies consider before and during implementing a blockchain protocol?*

3. **How can companies benefit from using blockchain?**
   1. *How does blockchain compare to current IT-systems in information sharing?*
   2. *What kind of data/information should blockchain be used for based on certain aspects of information sharing?*
4 Methodology

In the following chapter the approach for this thesis is outlined, followed by the chosen course of action with explanations on the different phases the study goes through. Which type of data and how it was collected is explained, followed by how the research questions was answered. Finally, the methods the authors have worked with for achieving credibility is explained.

4.1 Approach

From an academic point of view the area surrounding blockchain is a rather unexplored area. As well as its connection to other technologies and to supply chain and logistics. This infers a thorough description of blockchain is needed to be able to attain the necessary knowledge to conduct the comparisons and make the connections to information sharing within a supply chain. This means that the thesis takes the form of both descriptive concerning the technology and explorative concerning its use. Björklund & Paulsson (2012) explains that a descriptive study, is used when there is fundamental knowledge and understanding of the area, and the objective is to describe but not explain relationships, while an explorative study is used in an investigating manner to gain fundamental knowledge.

Qualitative studies aim at creating a deeper understanding for a specific subject, whereas a quantitative study comprise of information that can be measured or evaluated numerically. It is mainly the purpose of the study that determines which approach should be used. (Björklund & Paulsson, 2012)

Since the purpose of this thesis is to explore the potential blockchain can have on information sharing, consequently creating a deeper knowledge and understanding of a specific subject, this study is of a qualitative nature.

4.2 Research process

The research process that has been followed in this study is a modified version based on the structure The Wahlbinian U presented by Lekvall & Wahlbin (2001), see Figure 8: The study's modified research process, and is described further in the following chapter. The model was chosen due to the fact that it represents a typical research process, with the ability to be adapted for different studies’ specific needs, and explain how the different parts are connected.

The model was further divided into four phases, the planning phase, empirical phase, analysis phase and conclusion phase. In the model, the connections between the parts are shown to make it clearer how the parts connect as a whole, which will also be explained further below.

Even though the research process followed these phases each research question is presented with a compilation of gathered information, analysis and results before moving on to the next question. Thereafter, the conclusions concerning the purpose of this thesis is presented.
4.2.1 Planning phase

The study began by identifying blockchain as a disruptive technology that could have great impact on how supply chains operate, however, that the widespread knowledge about the technology is low. This formed the overall task of the study, from which the purpose was derived. The formation of the problem in the background and the purpose of the study is directly linked to reflections that are based upon the analyses and conclusions, which also are directly connected to the purpose.

The next part of the research of literature was to form the theoretical framework which was an iterative process resulting in the delimitations of the study and narrowing of the scope. Which led to the main focus during the planning phase, to break down the task in further detail so that the right research questions could be formed and consequently what methods that should be used to answer them.

The precise task of the study is directly linked to what analysis was made and underbuilds the conclusions that was drawn. The research method is connected to the gathering of empirical data and analyses because it states what data that needed to be collected, how it should be processed, and what methods for analysing the processed data that should be used.

4.2.2 Empirical Phase

During the empirical phase, the gathering of primary data took place. Interviews and surveys were conducted to get specific data concerning this study. Compilation of data was continuously carried out throughout this phase. With the interviews, the authors hoped to get first-hand information from experts that work with blockchain daily to gain deeper knowledge and insights to use in the analyses. The survey was used to get the companies perception of what they find important in regard to information sharing in their supply chain. The data was
combined with important parts of the theoretical framework to form a compilation of the gathered information.

4.2.3 Analysis phase
Once the information had been collected and processed, the analysis and discussions concerning the gathered information and research questions took place. The analyses are based on the theoretical framework and the gathered data presented in the compilation of gathered information sections. The analysis for the first research question include connections between blockchain and information sharing as well as to other digital technologies. For the second research question the analyses focus on how companies could adapt a blockchain protocol into their business. For the third research question, the benefits from using blockchain was analysed.

4.2.4 Conclusion phase
When the analyses concerning the research questions had been made and the results had been presented the last phase started, where the conclusions was drawn based on the previous phases, together with a reflection concerning the findings in this study. It is in this phase the purpose of the thesis was answered.

4.3 Methods for collecting information
Björklund & Paulsson (2012) presents literature studies, presentations at lectures and conferences, interviews, surveys, observations, and experiments as some of the most common methods for collecting and processing information and data in scientific papers. The gathering of data can be performed qualitatively and quantitatively, and the information is either primary data or secondary data.

Since this thesis is mainly a qualitative study, the methods that were chosen to gather information are literature studies and interviews. In addition, a survey was conducted to collect some quantitative data for the analysis model.

4.3.1 Literature studies
Relevant, reliable and sufficient information is needed to make correct conclusions (Eriksson & Wiedersheim-Paul, 2014). Björklund & Paulsson (2012) argues that a strength of literature studies is the possibility to gather lots of data quickly, and can be used to map existing knowledge within the area. However, the information is secondary data, which means it originally was used for another purpose that the current study and could be slanted in some way or not comprehensive. In addition, the methods for searching literature, for example which databases and words that are used can possibly lead to the research base being inconclusive. (Björklund & Paulsson, 2012) A representation of the conducted literature research was made to maintain credibility throughout the study, presented in appendix 1. By studying references in books and articles, also known as snowballing, a better and more comprehensive understanding of the studied areas were attained.

The most recent discoveries and information can usually be found in articles, reports and conference proceedings (Patel & Davidson, 2011). Most of the information concerning recent technologies and advances were thereby collected using these kinds of sources. Consultant reports and websites were also used to gain more information. However, these were used with more caution as the risk of slanted or not comprehensive content were greater.
The books used in this study were gathered from Linköping University Library and from the Logistics Department. The primary searches for electronic sources have been through UniSearch and Google Scholar. However, the peer reviewed literature concerning blockchain and some of the more recent developments in digital technologies was scarce, which lead to the need of information gathering through consultant reports and websites.

**Search method**

The primary source to gather information was UniSearch, a search service provided by Linköping University Library to search multiple databases through a single access point. The first action was to use advanced search and limit the results to peer reviewed journals and to those where full text where available online. The search key was set to title in the first search. To find if there were any connections to logistics or supply chain, the second box was filled with just “logistics OR supply chain” and in the first search the key was set to title, if the results were too few, it was set to abstract to widen the perimeters. The next step was to let the search key be on “optional”. If not enough sources were found or if the quality was inadequate, the steps were repeated, without being limited to peer reviewed journals.

When looking through the results a first screening was done from the titles, if the title was of interest for the intended use, the abstract was read. If the source still seemed of interest the full text was read.

The next step in the process, if not sufficient sources were found was to use, Google Scholar with the same key search words. If there was still a lack of information, google was used to find consultant reports and websites about the topic of interest. However, in order to build legitimacy in the sources used, the authors of these consultant reports and the reports from the websites were investigated further to see if they had any past experience with given topic.

For information about supply chain, the primary sources were books attained from the Logistics Department, these were used for the basic understanding for supply chain in combination with books and articles used in the Supply Chain Logistics course given at Linköping University. To dig deeper in to the information sharing aspect, the multiple database system mentioned earlier, UniSearch, was used. Information sharing is a very broad topic and in order to narrow it down and to get a closer connection to Supply Chain Logistics, connectivity and willingness were included in the search. An important factor to consider was the categorization of the term’s connectivity and willingness into the so called “aspects”. These were taken from several different sources where some of the categories were mentioned more frequently and expressed as more important than others, which resulted in them being picked for the method. To give an understanding of how widely covered Supply Chain is, when the terms are included in UniSearch as abstract or title,

When it comes to the main purpose of this report, blockchain, the literature search was quite different than for the other parts. Blockchain is a state-of-the-art technology and has very few academically documented connections to supply chain. Therefore, the search to explain blockchain was for the most part focused around white papers, especially when it came to the consensus mechanisms. As blockchain had a soaring popularity in 2017, a lot of new tweaks of the technology were introduced with new revolutionizing cryptocurrencies. Consensus mechanisms are constantly being developed by cryptocurrency enthusiasts. This creates a risk for the white papers to over-sell the functionality of their technology. To avoid including non-verified technology, several literature researches were made and used in order to only include
the most relevant consensus mechanisms. Information in itself about blockchain came from various places, ranging from journals created by blockchain enthusiasts to the beginning of blockchain, The Bitcoin whitepaper.

However, in order to create a validity in the research, all information describing the technology and key characteristics of blockchain was either gathered from books written by renown people in the blockchain community, or by peer reviewed reports.

To give an understanding of how the different topics, blockchain, supply chain and information sharing, have been covered in form of research, a representation of search results was made. All terms were first separately searched for on UniSearch with the terms included in abstract or title. Additionally, only peer-reviewed articles were included.

For example, the search “supply chain” in the abstract or title, generated 112 979 results of peer reviewed articles, while the same search for blockchain only generated 3 399. This already illustrated how there is a difference in the amount of research conducted in the separate fields. To further the understanding of how the different topics intertwine, a combination of the terms two and two was made and finally a search for how many peer-reviewed articles that have been published with all the three topics mentioned in the title or abstract was illustrated, see figure below.

![Figure 9: Representation of initial search with number of results.](Source: own illustration)

### 4.3.2 Interviews

With interviews, the authors get primary data, which means data that has been gathered to be used in the current study. The interviews can be performed in different ways such as in person, over the phone or over e-mail. There are also different kinds of approaches for interviews, structured interviews, where the questions are determined beforehand, semi-structured interviews where there is room for improvisation, and unstructured interviews, that demand no preparation in regard to pre-written questions. (Björklund & Paulsson, 2012)

The interviews took place over the phone and by sending questions over e-mail, because it was not possible due to time or distance to conduct the interviews face to face. Björklund & Paulsson (2012) point out that the clear advantage with phone interviews is that the involved parts don’t have to be in the same place. While the risk of misunderstanding and misinterpretation is higher due to the lack of seeing reactions and body language.
The interviews conducted over e-mail had a structured approach as the determined questions were sent to the blockchain experts, while a semi-structured approach was used for the phone interview. Which means that the topics were predetermined and the interviewee was given freedom to formulate the answers. In addition, the questions may be formed as the interview proceeds based on the previous answers or reactions. (Björklund & Paulsson, 2012; Patel & Davidson, 2011) For this study topics and questions was prepared beforehand as much as possible, to be able to gain as much information and knowledge as possible from the interview, but also to be able to give the interviewee possibilities to shape the contents of the interviews without losing track of the goal with the interview. The interview was recorded to not risk missing any important information.

As mentioned in section 4.2.2 Empirical Phase the interviews were conducted with blockchain experts who work with blockchain on a daily basis, to gain insights on their perspective on the technology and to receive first-hand information on the possibilities and challenges they encounter. The thesis was sent to the blockchain experts to validate that the authors had understood the answers correctly and to minimize the risk of misinterpretation, this felt extra important for the answers received via email as this risk was deemed greater.

To maintain credibility in the answers from the interviews that was used to base a big part of the analyses and conclusions from, the blockchain experts that were selected to be interviewed had to have worked with blockchain on a daily basis for more than a year. There are many self-proclaimed blockchain experts to be found on Linked-In. It was therefore crucial to sift out the true expertise from the people riding the hype train in hope to generate fast income. This was made in three steps. The first step was to search for people who describe their work with the key term “blockchain” and give a quick glance of the people with a high amount of following, where a high amount is someone with more than 2000 followers. These people were contacted and asked to answer a couple of questions, either by phone or email. Once someone agreed to answer the questions, a further investigation of the “blockchain experts” was made to ensure that the answers that they would provide could be considered legitimate. This investigation was made by checking how long they have been actively working with blockchain-related projects, where anything below 2 years was considered inadequate, and also what they specifically focus on within blockchain, since there are many people who are very cryptocurrency orientated and are therefore not completely relevant for this research. The third and final step was to review the answers to consider if any bias could be considered before adding them to the research. This strict sift generated few, but very reliable sources. Below, a representation of how many people were contacted and how they were siphoned out step by step to result in four people.

Table 1: Representation of how Blockchain experts were chosen through LinkedIn and email contact.

<table>
<thead>
<tr>
<th></th>
<th>Initially</th>
<th>Made the cut</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Blockchain’ + 2000 Followers</td>
<td>More than 1000</td>
<td>93</td>
</tr>
<tr>
<td>Agreed to answer Questions</td>
<td>93</td>
<td>21</td>
</tr>
<tr>
<td>Passed further investigation</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>Answered</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Non-Biased/Adequate Answers</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

As can be seen, although a vast number of experts were reviewed, only a small number of experts made it to the end, which resulted in four blockchain experts. Worth mentioning is that
although many experts agreed to answer the questions initially, few actually did. Which is to be expected, as the questions were quite specific and, in some way, demanding to answer. The number of answers could have been higher, but in the balance between many answers and highly reliable respondents, the second were chosen.

Interview questions
The questions that were asked to the blockchain were based on the information that was needed to answer the research questions. The questions will be presented with a short motivation.

To gain validity in their answers a short presentation about themselves felt necessary combined with their experience of working with blockchain. This led to the first question:

- *Tell us a bit about yourself. What is your background in Blockchain?*

The authors were interested in their specific knowledge and point of view on the use of blockchain and their perception on the possibilities the technology can provide to companies.

- *According to you, what possibilities do companies have with Blockchain?*

Since the experts are used to working with blockchain and has been part of implementing blockchain in some manner, their view on what to consider before implementation and how the process could be performed would prove of great value to this thesis. Hence, the questions:

- *What should companies consider before looking to implement a Blockchain solution?*
- *What is the first step for a company implementing a Blockchain Solution? How could the whole process look like?*

To gain a wider perspective and insights on obstacles and challenges with a blockchain implementation from a first-hand source, the second to last questions became:

- *What are the biggest challenges for companies looking to implement a Blockchain solution?*

There is a wide variety of IT-systems in use today with plenty of differences, benefits and drawbacks. To be able to analyse and draw conclusions about how blockchain compares to other IT-systems in information sharing, the opinion on how blockchain compares in general were necessary. This formed the last question.

- *How does Blockchain compare to a current traditional IT-system, in regard to information sharing in your opinion?*

Blockchain experts
These questions were asked to a variety of experts. Those who answered our questions are presented below, by their answers on the first question.
Table 2: Presentation of the interviewed blockchain experts. (Source: Own illustration)

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Company</th>
<th>Interview form</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter Bunus</td>
<td>CEO &amp; Co-founder</td>
<td>CyStellar</td>
<td>Phone Interview</td>
<td>2018-11-26</td>
</tr>
<tr>
<td>Christopher Ferris</td>
<td>CTO of Open Technology</td>
<td>IBM</td>
<td>E-mail</td>
<td>2018-12-07</td>
</tr>
<tr>
<td>Leigh Gordon Ashlin</td>
<td>Head of Blockchain and Disruptive platforms leader</td>
<td>Accenture</td>
<td>E-mail</td>
<td>2018-12-13</td>
</tr>
<tr>
<td>Oliver Haines</td>
<td>Vice President</td>
<td>FreightWaves &amp; Blockchain in Transport Alliance (BiTA)</td>
<td>E-mail</td>
<td>2018-12-19</td>
</tr>
</tbody>
</table>

Peter Bunus

Peter Bunus is the CEO and Co-founder of CyStellar, a big data analytics and decision support company, working to improve data-driven decision making and predictive analytics for the precision agriculture, logistics and insurance sector. CyStellar is working with blockchain to increase traceability of the data they handle, as well as using blockchain for food traceability applications and applying it to food supply chains.

Christopher Ferris

Christopher Ferris is an IBM distinguished engineer who has worked with engineering and distributed systems architecture for a majority of his 39-year career. He has as the CTO of Open Technology the overall responsibility for all of the open source and open standards work at IBM.

Leigh Gordon Ashlin

Leigh Gordon Ashlin is the Head of Blockchain and Disruptive platforms leader at Accenture.

Oliver Haines

Oliver Haines is Vice President of both FreightWaves and Blockchain in Transport Alliance (BiTA). He is working with business development for BiTA and has more of a background in logistics as a coal trader, than a traditional technical background.

4.3.3 Surveys

Björklund & Paulsson (2012) explain that surveys comprise of a set of standardized predetermined questions and options for answers. For example, the options can be graded on a scale from 1 to 5, yes/no-options, but the respondent can also be given the possibility to answer more openly and descriptively. Eriksson & Wiedersheim-Paul (2014) expresses that a relatively big survey has given answers for most questions but are complemented with open questions when, for example, there are too many answers to be listed, or the answers cannot be predicted beforehand. In this study, a grading scale from 1 to 7 is used in the survey to receive more precise data from the choices, and also leave the possibility to comment if the respondent has anything to add. Questions about which data the respondents are least willing to share and
which data they perceive the suppliers and customers are least willing were also asked. Björklund & Paulsson (2012) mean that how a survey is conducted in terms of, how it will be sent, to whom, and to how many, depends on what is found optimal acquire the answers to the asked questions. In this study, the survey is used to validate information the authors have gathered from literature and attain the focal companies’ perceptions about information sharing for the analysis phase and for the qualitative analyses. The survey was sent to supply chain managers at companies at different parts of a supply chain to gain different perspectives. The survey layout can be found in appendix 2.

Conducted survey
The survey consisted of two parts, in the first part the managers were asked to fill out the importance of the aspects of information sharing, on the scale from 1 being unimportant to 7 being very important, concerning certain data sets. If they were unsure or any on the data or aspects did not apply to their business that option was available.

Table 3: Representation of the form in the survey (Source: Own illustration)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>Accessibility</td>
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<td>Trust</td>
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<tr>
<td>Commitment</td>
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<tr>
<td>Reciprocity</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

This table was answered for the following types of data:

- Inventory information
- Sales Data
- Sales Forecasting
- Order information
- Product Ability Information
- Exploitation information of New Products

In the second part the managers were asked to answer the following questions:

*How does your company share information with suppliers and customers today? What kind of IT-systems do you use?*

*What kind of information are you least willing to share with suppliers and customers?*

*What kind of information are your suppliers and customers least willing to share with you?*

23 supply chain managers were contacted, 11 of them approved to answer the survey, where four answers were received. Out of these four answers, one respondent agreed to a short interview to discuss the reasoning for the answers. There was a wish to get more answers, however it was very time-consuming and gave little reward. The answers from the managers were intended as a way to validate the theories and aspects for information sharing in this thesis. The fact that all of the aspects were rated highly by the respondents combined with the fact that none of the respondents had any aspects to add, led to the number of answers to be deemed enough. The respondents are supply chain managers, a logistics projects manager and a VP of
operations and supply chain. The companies work in different parts of supply chains as wholesalers and producers of finished goods and from both food and manufacturing industries.

4.4 Methods for answering the research questions

This section discusses and presents the methods that was used to answer the research questions. Each research question is re-presented before the methodology for that separate question is answered. By answering the research questions, enough knowledge was attained to answer the purpose of the thesis.

The overall goal is to answer the research questions and tie together the areas of blockchain and supply chain that has been handled separately this far. Some different approaches to these areas and where and which data that was used to answer them will follow. Concerning the first research question a big part of the answers was drawn from the information presented in theoretical framework, and partially from interviews. The answer to the rest of the questions was to a great extent based on answers provided by blockchain experts. Information concerning supply chain and information sharing mainly come from the theoretical framework, and input from answers on the survey was mainly used to validate parts of the theoretical framework, or observations and theories the authors had. The table illustrate which parts that are used to answer the research questions.

Table 4: Illustration of which data will be used to answer the research questions. TF = Theoretical Framework. (Source: Own illustration)

<table>
<thead>
<tr>
<th></th>
<th>TF 2.1</th>
<th>TF 2.2</th>
<th>TF 2.3</th>
<th>TF 0</th>
<th>Interview</th>
<th>Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>RQ2</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ3</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

4.4.1 What is Blockchain?

By answering the first research question the authors aim to create a fundamental understanding of blockchain for companies as well as further explore and describe the technology enabling blockchain.

In order to answer this question, thorough research had to be made regarding the technical aspects of blockchain as well as the functionality. In regard to new technology, most of the information was collected from articles, white papers and conference proceedings. As the academic research is limited for the given area, some of the collected information came from consultant reports and websites.

The method to answer research question one is built on three levels. The first level is the basic information gathering of blockchain, specifically a description of key terms in blockchain to create a basic understanding and an eagerness for an in-depth exploration, only hinting at the potential of blockchain. At this level, the information gathered is quite elemental and is verified through multiple sources.

The second level is a careful study of the underlying technology in blockchain. This level is more technical and challenging for someone unfamiliar to blockchain technology. Since blockchain is a new complex system, a lot of the information gathered is closely connected to white papers generated for cryptocurrencies. This information has been handled with extra
caution since many white papers aim to advertise their new concept, especially with the soaring popularity of cryptocurrencies during 2017. (Stanley, 2018) By offering a more intricate description of blockchain, going in on the mechanisms enabling the true value of blockchain, the reader should gain enough knowledge to start contemplating on new areas where blockchain could be applied.

The third and final level of the first research question is to give examples of utilization areas where blockchain has currently been implemented. In order to contribute with knowledge of the diversity and the value of Blockchain as well as the potential, a wide range of Blockchain solutions is presented. The challenge lied within finding examples that have comprehensive description of what they specifically use Blockchain for and how. As many companies implementing Blockchain are the first ones on their market, a detailed description is rarely sighted, as companies might find that they give away their advantage over their competition. (Suprunov, 2018) To emphasize the versatility of Blockchain, in this level of the first research question, an example from finance, retail, food and supply chain are described as well as the value that the company hopes to achieve.

To answer the sub-questions How does Blockchain relate to other digital technologies? and How does Blockchain relate to information sharing? the three levels used to explain blockchain, combined with the interviews, a case provided from the phone interview and the information about the digital technologies presented in section 2.4 was used.

4.4.2 How can companies implement a blockchain protocol?
The second research question aims to evaluate how companies should consider their options before deciding on their Blockchain protocol layout.

By further investigating the functionality of blockchain technology and what factors affect adaptability, this research hopes to evoke the correct mind-set for companies. This will partially be provided by literature reviews and partially from interviews. From literature reviews, this report aims to identify what pillar stones decide the functionality of a blockchain. This demanded an in-depth research of how blockchain can be adapted, and if it can be adapted in a way that suits the implementing companies. Furthermore, by interviewing blockchain experts, this report aims to show what companies have to expect from an implementation.

4.4.3 How can companies benefit from using blockchain?
The final research question compares currently implemented IT-systems with the potential Blockchain has to contribute with. This question aims to answer where blockchain can prove beneficial for a company and be used as a complement or replacement for current systems to improve their business and supply chain.

Additionally, to the knowledge gained from blockchain experts, a survey was conducted to identify what companies find important in their information sharing processes. This was to strengthen the need for a blockchain solution and to highlight the importance.

The final research question is divided into two consecutive steps. In information sharing, connectivity and willingness are essential. In this report, connectivity and willingness have been categorized into key factors. Therefore, for the first part of this research question, Blockchain and IT-systems was compared based upon these key factors. The conclusions made came partially from earlier research and literature review, but for the most part from Blockchain experts as well as from companies that have adapted Blockchain in their own Supply Chain.
Table 5: This table is a representation of the first part of the final research question, where IT-systems will be compared to Blockchain based on the different aspects in information sharing. (Source: Own illustration)

<table>
<thead>
<tr>
<th></th>
<th>Blockchain</th>
<th>Current IT-systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td></td>
<td></td>
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<tr>
<td>Accessibility</td>
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<td>Trust</td>
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<tr>
<td>Commitment</td>
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<tr>
<td>Reciprocity</td>
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<tr>
<td>Power</td>
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</tbody>
</table>

The second part of the research question aims to conclude how different information in a supply chain has disparate traits and therefore should be handled differently. The research conducted for this part of the question was done by conducting a survey where companies with supply chains got to rank how important they think the key factors from connectivity and willingness are for a certain information data.

Once both parts of the data are collected, it was compiled to see what companies consider as the most important aspects of each information/data-type. This in combination with the first part of the research question generated a result where companies will get an idea, supported by qualitative data, where blockchain could compensate for some flaws of IT-systems.

4.5 Achieving credibility

Björklund & Paulsson (2012) and Eriksson & Wiedersheim-Paul (2014) present the three aspects validity, reliability and objectivity as measurements of credibility in a scientific study. Björklund & Paulsson (2012) has defined the terms as presented below:

- Validity: to what extent the measured is what was supposed to be measured.
- Reliability: the extent of trust and stability in gathering methods, i.e. if the results will be the same if the research is repeated.
- Objectivity: to what extent values affect the study.

Figure 10: The image shows the concepts of validity and reliability. Illustrates the concepts of validity and reliability. In the image to the left, both the validity and the reliability is low. In the image in the middle the reliability is high, but the validity is low. In the picture to the right, both validity and reliability is high.
Björklund & Paulsson (2012) expresses that for every study, the goal should be to gain as high validity, reliability and objectivity as possible, however the use of resources to do so must be considered. The three aspects of credibility have been central throughout this study, and the authors have worked with triangulation, which is when more than one source of data or methods is used for the same purpose, as a way of increasing the validity and reliability. Furthermore, as yet another way of increasing the validity and reliability, clear questions and topics were formulated before the interviews and surveys. The questions were double-checked by at least two people before the interviews to avoid slanted or unclear questions. A precision of the target groups for the survey and interview were also made to increase validity. By asking the same questions to different people, the reliability is increased. The choices made in the study are motivated as a way of ensuring objectivity as well as a fair representation of gathered information to make sure the facts are correct and not chosen just to suit the authors point of view.

In this thesis, the authors chose to gather information from experts who work with blockchain on a daily basis to get their insights and views on the possibilities and challenges with the technology. This approach was deemed to get a good representation of the technology and how it has developed to where it is today from the side of exploring the potential. To get another side of blockchain, interviews with IT-experts who has chosen not to work with blockchain could have been the next step, to get an outside view on the technology and their reasons for not choosing blockchain.

The answers of the survey, even though the answers were few, could be used to validate that the chosen aspects of information sharing are important. However, the lack of understanding of the reasoning behind each answer led to limited insight and further analysis. With more respondents and more interviews to understand their reasoning, deeper analyses would have been possible. There is always a risk with few respondents to get a slanted representation of reality. However, there has been plenty of research within the area of these aspects and information sharing. Because of this, a combination of peer reviewed literature as presented in Appendix 1 resulted in the chosen aspects, and the survey served as a compliment with primary information for this study.
5 What is Blockchain?

The answer to each research question is divided into three chapters, Compilation of gathered information, Analysis and Results. In the compilation of gathered information, the obtained information regarding the research question is presented. For research question one in particular, a short summary is made from the information gathered in the theoretical framework. Furthermore, the information obtained from the blockchain experts is presented. In the second chapter, the analysis, the gathered information is analysed. In the third and final chapter, the presented results are short and concise and are discussed further under the chapter Reflection.

The sub-questions for this research question are:

1. How does blockchain relate to other digital technologies?
2. How does blockchain relate to information sharing?

These questions are answered separately in the compilation of gathered information and analysis chapters and together in the results chapter.
5.1 Compilation of gathered information

This question was researched and answered in three areas, Basics of blockchain, Underlying technology of blockchain and Utilization areas for blockchain. This is a summarized version of the information presented in the Theoretical Framework. To answer the following sub-questions, relevant information from the interviewed blockchain experts will be presented.

5.1.1 Three levels of blockchain

Basics of blockchain

Blockchain is a digital ledger that is updated to all nodes on the system in real time and allows value to be traded on a Peer-to-Peer network without the need of a third validating party. A digital ledger is the storage of transactions and interaction digitally. The Peer-to-Peer network is the possibility to directly interact on a network erasing intermediaries. Additionally, since blockchain is formed to not reward dishonesty, the trustless system eliminates the need of a validating party.

A blockchain can be either Private, Public or a mix of both. The difference is whether the blockchain is allowed for everyone to participate in or for a limited group of people. The authors (Gupta, 2018), (Zheng, et al., 2017) have divided the key characteristics into:

- Consensus
- Traceability (Provenance)
- Immutability
- Finality
- Decentralisation
- Persistency
- Anonymity
- Auditability

Based on the information provided in the theoretical framework, summarising the characteristics consorted blockchains have, especially being highly secure, and the purpose of streamlining processes in supply chain logistics, the two key characteristics auditability and anonymity are disregarded. The reason is as they don’t contribute to the purpose of supply chain logistics or consorted blockchains, where anonymity is even considered counterproductive. Furthermore, provenance has throughout this master thesis been called traceability.

Simplified description of the underlying technology of blockchain

The functionality of blockchain is enabled through the unique underlying technology. Blockchain technology could in a very simplified way be described as an output algorithm that needs to be solved in order to connect the record of a new transaction to the network. These records of transactions are called blocks and the connections are called chains, hence the name, blockchain. Since all new blocks are timestamped and connected onto the network, it creates one ledger that is updated in real time on the whole network, meaning, everyone has the original ledger. To verify the transactions, blockchain uses a consensus mechanism, that can differ depending on what the purpose of the network is. Consensus mechanisms are algorithmic solutions that generate validity to the transactions without the need of a third party. By creating an algorithm that is unique for a specific transaction, which can be solved through computational power, person A and person B can trade value on a blockchain network. As an
addition, there is a possibility to generate automated transactions, with predetermined terms, through enforcing algorithms called **smart contracts**. A smart contract, simplified, is a line of code that removes the need for contractual clauses or a controlling third party. For example, if party A and party B have agreed to trade two apples for three oranges on a daily basis, the trade will only occur if both party A and B keep their side of the bargain, eliminating the possibility for either of the parties to trick the other. There is also a possibility to encrypt the information on the smart contract and still verify it correctly through consensus mechanisms, meaning that the terms of the trade can be kept private between parties involved while still being stored on a blockchain.

**Utilization areas of blockchain**

Since the blooming of cryptocurrencies, the focus around blockchain technology has mostly been on the financial sector. However, as mentioned in chapter 2.3.7, there have been multiple use-cases for blockchain, for both private use as well as public. For the private use-cases the dominating factor has been gathering traceable data on a platform where it is securely stored and easily accessible. Since blockchain provides an immutable digital ledger, companies can provide a certainty in the validity of their information. For public cases, blockchain has been used to provide transparency or decentralise systems and minimising the need for intermediaries.

5.1.2 How does blockchain relate to other digital technologies?

Technology has lately started to develop in an exponential pace, challenging companies to utilize these technologies to gain an advantage over their competitors. In order for companies to utilize these technologies, they have to have a basic understanding of how these different technologies work, but also how they relate to each other. An important note is that since all of these technologies are quite new, they are changing rapidly and are therefore hard to grasp. (Bunus, 2018) To provide some understanding of how different emerging technologies can be used efficiently together for different applications in a business process, a case of one of CyStellar’s solutions will be presented.

**CyStellar – A Multi Technology Solution**

CyStellar is a company with the motivation of using state of the art technology to provide their customers with better insight for their businesses using data. Consumers are expressing a growing concern in regard to the origin of their food. A general distrust has evolved in regard to certificates and what they are based on. Furthermore, farmers have to go through lengthy processes to acquire a certificate, a process which can often be expensive. CyStellar provides an interesting solution. Through satellite imagery and IoT-sensors, CyStellar collects information from farms to prove that the produce is ecologically produced. The IoT-sensors are used to measure the levels of for example fertilizers, to make sure that produce stays within the levels required to be considered ecological. The satellite imagery is used to prove that the location of the produce is moved every year, a common requirement for ecological produce. This is the first part of the chain, the collection of information.

The images need to be processed to extract the necessary information. This is done seamlessly by sending the information to the cloud where the analytics platform analyses of the data. These analyses are done by artificial intelligence, which then return answers of the analysed data, for examples if the crops have been rotated. This processed data is then stored on the blockchain together with the data gathered from the IoT sensors.
When it comes to issuing the certificates, the certification authority can be connected to the blockchain where all the necessary data already exist. A certificate can be issued by the help of a smart contract which can be programmed to execute when all the conditions are fulfilled by the farmer. The blockchain is thereby used to store and transmit data in this case, and is used as an automation tool for an otherwise time-consuming and expensive process.

The way the certification process was carried out before CyStellar and still is for a lot of farmers is that everything has to be done manually. The certification authority has to send an inspector to the farm to manually gather data on the conditions the farmer has to fulfil to receive the certificate. For example, the inspector has to make sure that the farmer moves the produce around, which is difficult if no data of past years is available. After this, the information is provided to the authority that reviews the content and issues the certificate.

![Figure 11: Traditional certification process.](Source: Own illustration)

With the solution provided by CyStellar, there is no need for manual input of data once the conditions for the certificate have been decided upon. Additionally, to this automation, blockchain provides a unique solution for consumers, as consumers argue that the legitimacy of the certificates as they cannot retrace the process conducted of the farmers acquiring the certificate. Since the information stored on a blockchain is both traceable and immutable, the consumers can with certainty retrace the origin of their food and the legitimacy of the certificate, benefitting the farmer as well.

![Figure 12: Certification process with the solution provided by CyStellar.](Source: Own illustration)
5.1.3 How does blockchain relate to information sharing?
To illustrate how the information sharing on blockchain works, a visual comparison between blockchain and current IT-systems can be seen below.

As can be observed below, the information flow in regular supply chains with the use of traditional IT-systems is in series. The information is not shared between all parties of the supply chain, which makes the information of the produce secondary at best for end consumers.

![Figure 13: Illustrates how the information flows in a supply chain, in a simplified way. (Source: Own illustration)](image)

When it comes to information sharing on a blockchain protocol, all parties involved share the information through storing it on a blockchain protocol. A blockchain protocol can then be formed in a way to allow the right companies to the information they need.

![Figure 14: Illustrates how information flow can be viewed on a blockchain. (Source: Own illustration)](image)

According to the blockchain expert, Bunus (2018), who is currently implementing and utilizing blockchain solutions, people often express a concern of needing to understand every single part of the technology in order to utilize it. This however, should not be the case, he gives an example of how blockchain should be regarded as email or other day to day tools used on the internet, people should know how to use it, but do not have to know how it works backend.

Bunus, who is one of the founders of CyStellar, uses blockchain to store information securely and automating transactions according to pre-set conditions. He continues by saying that the uniqueness of blockchain provides him the possibility to prove the origin of data as the digital ledger cannot be tampered with. Additionally, by the power of smart contracts, CyStellar, provides a solution that can generate certificates for farmers who want to prove that their produce is eco-friendly. This according to Bunus is an increasing trend among consumers abroad, as more and more people are sceptical toward the origin of food and how it is produced. Blockchain also contributes with a system that prevents double spend. Therefore, Bunus mentions that this is useful when using data and making sure that it is not used twice. CyStellar uses the blockchain protocol for unique parts of their information sharing.
Overall, Bunus sees the biggest potential for blockchain in information sharing is the possibility to trade and share value with parties that you don’t have to trust in the day to day operations.

According to Ferris (2018), blockchain offers a technology platform that can transform many industries. As with most emerging technologies, blockchain is also over-hyped and while there are a number of use cases that could be applied, many make little business sense or would offer little return on the investment. Ferris continues by expressing that there is a significantly overblown hype around token economics (economics regarding digital currency) and an exuberance over how tokens might disrupt this or that. The reality is that most of these will fizzle (or worse, collapse in a steaming mess that will leave many wondering where their investment went). Ferris believes that there will be a Darwinian process, that will leave a few successes and that most of these will have pursued a path that treats the token as a security and plays by the existing regulatory regimes that apply.

Furthermore, Ferris (2018) stated “I also think that there will be some DLT (Distributed Ledger Technology) projects, especially those that are automating processes that are presently not automated, or addressing processes that are currently bereft of trust, that will also survive the hype cycle’s troth of disillusionment and become viable in their own right.”

Ashlin (2018) suggests blockchain will be utilised in different areas. Just as Ferris (2018), Ashlin believes that the uniqueness of blockchain will create new ways of recording information. Furthermore, Haines (2018) suggests that the different areas might be changed in aspects such as lower transactions costs, speeding up processes and providing security and trust. Haines also discusses the possibility to free up capital through blockchain technology.

5.2 Analysis

Although the theory generated in the theoretical framework created a good understanding of what blockchain is, the conducted interviews created a more wholesome comprehension of what blockchain is and isn’t and how blockchain is apprehended by companies. During the interview with Bunus, one of the first things he said is that a lot of companies are solely trying to utilize blockchain for a marketing purpose, without actually successfully using the technology. It is also very difficult to completely grasp the technology of blockchain. Currently, a lot of people are turning to blockchain out of interest and the sector is booming in popularity, creating more and more knowledgeable people, however, as it is changing and rapidly evolving, it is nearly impossible to be an expert on the whole field. This also creates a conflict between experts within the field on what the true purpose of blockchain really is. While searching for blockchain experts to help provide knowledge, some even expressed that they did not want to conduct an interview for the simple reason that they did not believe in the connection between blockchain and supply chain. Although the technology is comprehensible, there is still a conflict on the utilisation area for blockchain to a certain extent. This is also in line with the concern that Ferris expressed, blockchain is an over-hyped technology, therefore, just as with internet, the true purpose will expose itself more clearly once the technology stabilizes. On a less pessimistic note, as Bunus has proven, blockchain already has many utilisation areas where it has proven to be useful and a viable business addition.

5.2.1 How does blockchain relate to other digital technologies?

Connectivity relates to the IT part of information sharing as it enables companies to collect, analyse and disseminate information, as presented in section 2.2.4. In addition, data needs to be stored somewhere where it can be accessed on demand. These four terms make up the model
in which the authors will analyse the relationships between information sharing and the technologies presented in section 0.

Something Automatic Identification and Data Capture (AIDC), Cyber-Physical Systems (CPS) and Internet of Things (IoT) have in common is the ability to gather data autonomously, however, they do so in somewhat different manners depending on the specific functions of the device itself. Therefore, these technologies can be seen to have a tight relation to the term collecting. IoT has also the possibility to interact with other objects and share information, which is why it also can be related to disseminating information.

Since Big Data can be seen as the set of already collected data from different sources in different formats it has already surpassed the collecting phase. Of course, this data needs storing and can be seen as the storage of these immense datasets. However, the raw data itself is not very useful. Its usefulness lies within the opportunities it provides with more advanced analyses to provide datasets with high value. Big Data & Analytics can therefore be seen as part of the analysing of information as well as storing.

Artificial Intelligence (AI) is technology that learns from iterative processes to perform a certain task. To work properly AI needs a lot of data to learn from. AI is also capable of going through vast amounts of data and find patterns, identify images, perform tasks, analyse, and draw conclusions to become smarter and more efficient, which means it also can be used in the analysing stage of information sharing.

Cloud computing is a wide concept, with many possibilities in service models and deployment models. Applications can be run on the cloud to analyse or share data. It can be deployed to be managed and operated by multiple parts, it can be used to store data, can be scaled up or down to suite requirements, and it can provide access to the data for anyone from anywhere. It can therefore be considered to relate to both analysing, disseminating and storing.

Out of these connectivity aspects of information sharing, blockchain relates to disseminating and storing, more on this in the following section.

Table 6: Summary of how the technologies relate to the connectivity aspects of information sharing. (Source: Own illustration)

<table>
<thead>
<tr>
<th></th>
<th>Collecting</th>
<th>Analysing</th>
<th>Disseminating</th>
<th>Storing</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIDC</td>
<td>X</td>
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<tr>
<td>CPS</td>
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<tr>
<td>IoT</td>
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<tr>
<td>Big Data &amp; Analytics</td>
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<td>AI</td>
<td>X</td>
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<tr>
<td>Cloud Computing</td>
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<tr>
<td>Blockchain</td>
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</table>

In order to understand how blockchain interacts with other technologies it is important to first define two terms. When speaking of two technologies connecting, it simply means that they can interact in an efficient manner, however, it does not mean that they enhance each other. The second term is dependency. Dependency is the key term that expresses whether the technologies need each other or not. For example, as we know, AI needs vast amounts of data to improve and give a precise result. Therefore, a technology is needed that can generate that
amount of information and also store that kind of information. Blockchain on the other hand seems to be independent from other technologies. It can be used together with other technologies to form sort of a chain of technologies performing different tasks towards an increased automation. However, blockchain does not depend on these technologies to be able to fulfil its purpose. Which can be realised partially by analysing the current solutions on the market (CyStellar included) but also how the technology has evolved. For example, a lot of technologies that are considered trendy, such as big data, AI and cloud computing, have all emerged from a soaring amount of data. Blockchain however, was originally created with the purpose to change the way transactions were executed.

Based on the way blockchain is utilised in the examples presented as well as the conversations with the blockchain experts, there seems to be different areas for blockchain to be successfully implemented. In some cases, the technology is used for the unique ability to provide traceable information as well as certainty of the legitimacy of that information. There is also an automation process within the technology of blockchain. As mentioned in the case of CyStellar, through smart contracts, there is a possibility to automate the verification process of certificates. This makes blockchain a part of a chain of technologies, where blockchain seems to be the only technology able of verifying transactions without the need of a third party. Ferris (2018) expressed that this aspect of blockchain is most probable to make the technology succeed, as everything that can be automated will be automated.

5.2.2 How does blockchain relate to information sharing?

The chains in information sharing, as mentioned before, are divided into collecting, analysing, disseminating and storing. Blockchain has been utilised in many industries in various ways, however, the functionality of blockchain is limited to transmitting and storing information. This is probably what creates the biggest confusion with blockchain, but is almost one of the most important parts. As the hype of blockchain exploded during 2017, there did not seem to be any limit to this technology, where some even compared it to being as revolutionary as the internet. (Shaikh & Lashari, 2017) However, as these technologies mature, the utilisation area becomes clearer and companies realise the true value. Ferris said it best, blockchain will experience the “Darwinian process”.

The first step in the Darwinian process, at least for the application within Supply Chain, has been what purpose blockchain can serve and in what way. Furthermore, as companies look to improve the efficiency of their supply chains, the flow of information will become more and more automated. Since blockchain has the unique possibility to validate transactions without a controlling party, companies will, through a consorted effort, be able to trade information in an automated manner. The challenge will be to agree on terms generating profit to all parts of the supply chain. As for the storing part, blockchain has a unique capability in storing information, mostly for immutability, information tracing and transparency. Therefore, the Darwinian process for blockchain in supply chain logistics will be to further what parts in information transmitting and - storing blockchain will generate value. Based on this, the challenge will be to categorize transmitting and storing information and identify more specifically what parts blockchain will change.

Haines (2018), as presented in the compilation of gathered information, stated that blockchain has the possibility to improve security and trust but also to create efficiency in a supply chain, both for cost and time as well as free up capital. The especially interesting part of what Haines
stated is the “free up capital”-part. Companies part of a supply chain often find themselves in big financial investments for merchandise they have not received. Blockchain creates the possibility to automate the payments once the merchandise has been produced, shipped or delivered, depending on what you agree upon in the supply chain. This is made possible due to the efficient way blockchain has of transmitting information. It is also interesting to consider Haines statement in regard to streamlining the supply chain in both cost and time. The transactional costs might be a game changer for supply chain companies, as controlling and validating transactions are done manually and are therefore expensive. As for the streamlining of flow in the supply chain, Haines (2018), Ashlin (2018) and Bunus (2018) all three see a value in creating new revenue streams by removing non-value adding parties. Meaning, that a process that can be avoided or automated is not adding value and blockchain can therefore help in eliminating such processes and therefore streamlining the supply chain.

A challenge for the use of blockchain in information sharing is also to quantify what value it adds. In the current state, a lot of companies try to use blockchain for risk management. This is connected to the storing of information that is immutable and traceable. This is highlighted in the Walmart case in chapter 2.3.7. There are no statistics in regard to what profit Walmart might gain from implementing a blockchain solution, if there are, they are probably not very accurate as such measurements are very difficult to conduct. Instead, blockchain in this case adds value by reducing both the risk of devastating failures occurring in the blockchain and also the efficiency in solving misdoings. This gives Walmart good marketing opportunities as they are able to validate the origin of their produce as well as the quality for the sake of their consumers, themselves, and anyone in the supply chain.

5.3 Results

The characteristics of blockchain that can contribute to a supply chain and logistics are:

- **Consensus** adds the ability to exchange information with a party on pre-set terms without the need for a controlling party, streamlining the information flow by reducing non-value adding processes.

- **Traceability (Provenance)** helps companies backtrack the origin of their data. By being able to retrace the data, companies’ part of a supply chain can more effectively manage risk.

- **Immutability** adds value to a supply chain by ensuring all parts of the supply chain of the authenticity of the data which provides a form of security, as transactions cannot be tampered with after they have been verified.

- **Finality** ensures all supply chain members that they have access to the latest update of information, as everyone on a blockchain has access to the original ledger.

- **Decentralisation** improves the information sharing on a supply chain by being able to share information in real time with the whole supply chain.

- **Persistency** minimises errors and in retrospect creates value to everyone on the supply chain by diminishing supply chain risk.

How blockchain relates to other technologies can be described as how it interacts and depends on other technologies. Although blockchain can be integrated into a solution with multiple technologies and work efficiently in an automated way, there is no evidence found in this
research on blockchain being dependent of any of those other technologies. Furthermore, even if blockchain in addition to other technologies can improve the flow of a business greatly, **blockchain in itself can solve problems, deeming it independent.**

This research has also identified that blockchain, based on the four terms of information sharing (collecting, storing, disseminating and analysing), can **create value in storing and disseminating information.** The possibilities with blockchain have created the possibility to operate on a more secure and trust-generating system. Which is closely tied to what blockchain is. A new IT-system which can generate trust and additional security on an immutable and distributed ledger.
6 How can companies implement a blockchain protocol?

For research question two, the compilation of gathered information is presented in a similar fashion as in research question one, with more emphasis on the information obtained by the blockchain experts. In the analysis, the information presented in the theoretical framework, in combination with the information presented by the blockchain experts is thoroughly analysed. Lastly, the results are presented.

The sub-question for this research question is:

1. **What should companies consider before and during implementing a blockchain protocol?**

The sub question is answered separately in the compilation of gathered information and analysis chapters, and together in the results chapter.

Based on the empirical findings combined with parts from the theoretical framework, this question both look into how companies can go about implementing a blockchain protocol and what they should consider before doing so. The empirical findings are blockchain experts that have shared their expertise of former implementations and what they consider are the biggest challenges. There is a comparison made if companies should implement blockchain technologies by themselves or to outsource the implementation to blockchain experts.
6.1 Compilation of gathered information

Emerging technologies have in the past been developed by a few companies that successfully implement and utilise these technologies at an early stage, as visionaries. For blockchain, the trend has been the same. Companies looking to implement blockchain are faced with a lot of challenges. Since blockchain is a fairly new technology and is rapidly changing, people with extensive knowledge are extremely rare. (Bunus, 2018) Furthermore, although the technology of blockchain protocol is public information, the adaption demands expertise in implementation to generate the unique abilities that blockchain is able to, such as immutable information storing.

Reasonably, there are only two options for companies, either they implement a blockchain solution themselves, or outsource it to blockchain implementation experts. The first option would mean that companies have to understand all technological possibilities, but more importantly, they would need to tweak the technology to fit their purpose and business model.

The second option is to outsource the implementation to a consultancy with blockchain experts and implementation specialists at their disposal. The increasing popularity has resulted in consultant companies trying to expand their knowledge in the field. However, there are also people describing themselves as blockchain experts with very limited knowledge on the matter. Which is in line with what Bunus (2018) said, some problems can be solved with the help of blockchain, but somebody needs to package the solution into something that can be used in a simple way.

What should companies consider before and during implementing a blockchain protocol?

Due to the overhype surrounding blockchain it is important for companies to thoroughly investigate what blockchain could contribute with to improve your business. Bunus (2018) expresses the importance of this as blockchain has unique possibilities, however, it should not be used by everyone. He usually tells people not to use it, as it is currently being over-used to solve problems, even though it might not be appropriate for that application, it might be an overkill, or it might not solve your problem. Companies should not get struck by the marketing possibilities available by getting recognition for utilizing this technology. Furthermore, Ferris (2018) expresses how there are only a number of use-cases for blockchain where many will make little business sense or provide a small return of investment. Additional to Christopher Ferris (2018), Oliver Haines (2018) expresses the importance to identify how the blockchain will be used. Therefore, a company should consider questions like:

- Do we have a database?
- Will there be numerous users updating the database?
- Is trust needed?
- Do transactions depend on/interact with each other?
- Are there problems caused by the use of a central third-party entity?
- Have we considered the implementation costs?

Once a company has answered these questions and identified an area where blockchain could provide a solution to an existing problem, or an improvement to an existing process, the next step is to identify how blockchain adds value to all parties in the process. This is the next challenge according to Peter Bunus. Especially for new technologies, as information sharing
enabling technologies must be used by all parties to be truly effective. This leads to the biggest challenge with the implementation of blockchain according to all interviewed blockchain experts, integration.

Continuing on the same track as Bunus (2018), Ferris (2018) says that the biggest challenge with implementing a blockchain solution is the “integration with existing systems and the assembly of a consortium of partners”. Ferris continues by saying that they call blockchain a “team sport” at IBM, meaning that in reality, to be effective, a blockchain solution needs a consortium of participants with common interests and a governance model (the layout of the blockchain protocol) on which all participants agree on. Ashlin (2018) expresses an importance of how a company should have an ecosystem first and that blockchain is a journey for the board of directors first and the company second.

Although, according to both Ferris (2018) and Bunus (2018), the biggest challenge within integration is social, there are some technical aspects that also create a challenge. To understand how to integrate the technology of blockchain, you have to be aware of the possibilities, however, as mentioned, Bunus (2018) expressed that it is not essential to understand every technological aspect of blockchain in order to utilise it. For example, a company that choose to create their own blockchain protocol must be aware of the differences in consensus mechanisms as well as the functionality. Depending on what your purpose is, the blockchain protocol will communicate differently and therefore verify transactions differently. Ashlin (2018) highlight that it is a big challenge, in order to enable the potential of blockchain partners, is the need to trust smart contract code, but who manages the code? Who makes updates? Is it a third party? Are they trusted? How is the payment for development divided? Who benefits most (value vs cost) from the ecosystem? These questions are essential to consider before moving forward with an implementation of blockchain.

Bunus (2018) says that they decide about the blockchain based on an assessment of the particular application, each time a decision is made about architecture or which type of blockchain to a trade-off is made. First of all, it is important that this decision and the trade-off make sense from a business point of view, and then they try to match the right technology. This is not easy since blockchain technology is still a moving set, with many things still changing, which from a technical point of view is kind of a nightmare for companies like his that are trying to use it and implement it for different applications. He furthers this by saying it is a technology for the future with a first mover advantage and predicts that it is a technology that will be used quite widely in the future. Companies should think about how blockchain can fit into their everyday business and how it will affect their business model. The technology might not be mature yet, to provide all the answers. However, like with the internet, it is important to start somewhere and then it will continue to evolve.

Bunus (2018) expresses that if your business consists of multiple actors that need to collaborate and make transactions, but do not trust each other, blockchain can be a potential technology to use for that purpose. Since blockchain will provide the trust that they otherwise do not have.

6.2 Analysis
As mentioned in chapter 6.1, companies have two options of implementing blockchain solutions, themselves or by outsourcing it to experts. Before making this choice, there are a lot of things to consider.
Based on the information provided by the blockchain experts, the biggest challenge in implementing blockchain solutions from a technical aspect is to find the expertise that is capable of adapting a blockchain protocol. Since blockchain expertise is a scarce resource, it is unlikely that you have a development expert internally. Therefore, companies have to find the technical resources either way. Therefore, unless that expertise sits within the company, the real choice is whether a company wants to hire blockchain experts to fulfil the specific request set out by the themselves, or if they want to outsource the whole implementation.

The first option means that a company has to be aware of all the technological possibilities with blockchain, and rather than describe a problem for the blockchain experts that they are looking to solve, they suggest a solution. This demands a vast understanding of blockchain and its technological possibilities. However, if the company possesses the competence, the blockchain protocol can be tailored to fit the supply chain. Furthermore, if a blockchain expert is hired as a consultant, as the technology changes, there is a possibility to constantly improve it and adapt it to its latest possibilities. This can be an effective option as Bunus (2018) stated, blockchain technology is constantly evolving at a rapid pace, meaning that the blockchain protocol could see improvements over time.

The second option is probably the more tested and currently the more viable one. Companies that have currently looked to implement blockchain have understood the potential of the technology, and that there is a unique utilisation area that cannot be matched by other technologies while not understanding to technology to its core. Therefore, they have utilised companies that are market leading in the implementation of blockchain, such as IBM. This is however a big investment for companies, and as expressed earlier there has to be a value in the investment.

What should companies consider before and during implementing a blockchain protocol?

One of the first questions a company considering blockchain need to work out is, can blockchain actually solve the problems we wish to use it for? As Ferris expressed, there are companies that look into implementations as a part of a marketing-hype around blockchain. As with any technology, it is important to start with understanding if the technology can actually solve the issue. If not, it will be a time consuming, expensive affair to implement a solution that will not provide the wished results. The company might just be better off looking into a different solution.

To be able to make that decision there are some factors that those in charge of deciding need information and understanding about. First off, as mentioned in chapter 2.2.4 under the subchapter Type of information shared, there is a presentation of how data can differ and in what way. The sharing of these types of data vary in both data volume, quantity of transactions, etc. It is therefore essential for a company to determine what kind of information sharing that blockchain will be used for. Consensus mechanisms, as stated by both Peter Bunus as well as from the theoretical framework, differ widely in speed and security depending on what purpose it is meant to serve. For example, CyStellar uses a fast validating consensus mechanism for micro transactions, while storing of valuable information is on a blockchain protocol with higher security and less speed. This trade-off is a decision that all companies have to take into consideration when deciding the layout of their blockchain protocol. Furthermore, it is important to take into consideration the latency and scalability aspects of consensus
mechanisms. Although there have not been any recorded cases of private/consorted blockchains experiencing these problems, as the Bitcoin protocol did, it is still advisable to take into consideration for bigger companies that trade large volumes of data.

The cost aspect is probably the most difficult part to evaluate. The cost of implementing a blockchain protocol will probably be higher than expected, since it is a new technology and expertise is a scarce resource, it is therefore imperative to make sure that the value generated will be long-lasting. It is also imperative to make sure that the problem a company is experiencing is best solved by blockchain. The hype surrounding the technology can be deceiving and create the illusion of blockchain being a necessity for all businesses. This is as the blockchain experts expressed, a bad idea for profitable businesses. Therefore, businesses should first see if there is an established IT-system that can be used to solve their problem.

Companies should also consider the team-work needed to have a successful implementation of blockchain. As Ferris (2018) said, blockchain is a team sport, therefore it is important that all companies are involved in implementation and are aware of what blockchain is and what purpose it will serve. It is also important to cooperate to make sure that the blockchain protocol is set up in a way that pleases everybody. Although a blockchain can automate processes and streamline the flow within the supply chain, it is important that the terms for the smart contracts and the overall layout of the blockchain protocol is formed in a way that suits everyone in the network. This expresses the importance of the previously presented area of importance of supply chain relationship. As stated by Sanders (2012), the technology for information sharing is only an enabler, you need to have a strong relationship with the partners in the network as well as trust each other. Furthermore, as blockchain is a big investment it is also important to consider the level of commitment that can be put on the relationship with certainty of the intentions of all parties involved.

6.3 Results

Before looking to implement a blockchain solution, companies face a couple of challenges. The first and most important one is to identify what problem you have and if blockchain can help solving that problem. There is no point in forcing a blockchain solution unto a problem that you can resolve in another, simpler, way. The second challenge is to identify what value a blockchain solution would add to all parties involved. Since blockchain is a distributed ledger it is especially important for everyone to see a value in using the technology. The third and final challenge is to realise the cost and difficulty of implementing a blockchain solution. The implementation must be made in unison as it is extremely important to agree upon the governing rules of the blockchain. Although companies might stumble upon more challenges, these are the three most important ones identified in the research.

Further to the challenges, there are also some technical choices that companies have to make. The most important one is whether the companies’ part of the supply chain should create their blockchain themselves or outsource the process to blockchain experts. In this report, the recommendation is to outsource the process, as a blockchain only is truly immutable if it is adapted properly and also due to the fact that it is highly unlikely that you have blockchain expertise resources internally. Another choice is connected to one of the challenges. Since a blockchain can vary widely, it is important to specify for what the blockchain will be used for in order to determine the layout of the blockchain. Once this has been completed, companies’ part of the supply chain need to unanimously agree on governing rules of the
**blockchain.** This is one of the most important steps, as a blockchain only serves a valuable purpose if all parties can experience a benefit from the blockchain. Furthermore, companies need to create a healthy plan on how changes can be implemented unto the blockchain protocol. If there is a need to update a smart contract or change a governing rule, all companies need to be aligned on how it will be carried out.

Companies that have completed these steps now face the most important part of the implementation, educating and getting all of the necessary individuals of the company on board. A blockchain solution will only be effective if it is used properly and for its purpose. Companies that have succeeded in this and started using blockchain also need to constantly look for improvements and consider it an iterative process.

These steps can be summarised into a process that can be found below.

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**Figure 15:** This figure illustrates the steps companies should follow when implementing a blockchain solution, starting with an introduction, followed by a technical adaptation and finally resulting in utilizing the blockchain solution.

(Source: own illustration)
7 How can companies benefit from using Blockchain?

Research question three is divided into the same three chapters, compilation of gathered information, analysis and results.

The compilation of gathered information in this question is based around three sources of information, the theoretical framework, the blockchain experts as well as the survey conducted towards to a small group of supply chain companies. The analysis and results are presented as in the previous research questions.

The sub-questions for this research question are:

1. How does blockchain compare to current IT-systems in information sharing?
2. What kind of data/information should blockchain be used for based on certain aspects of information sharing?

These sub-questions are presented separately in the compilation of gathered information and analysis chapter and together in the results chapter.
7.1 Compilation of gathered information

In the theoretical framework, there are a couple benefits mentioned in regard to blockchain. First off, blockchain builds trust. The trustless system of blockchain is, according to Gupta (2018), built around five attributes:

- *Distributed and sustainable*
- *Secure, private and indelible*
- *Transparent and auditable*
- *Consensus-based and transactional*
- *Orchestrated and flexible*

All these contribute to a trustless system with emphasis on the consensus mechanisms that allow for transactions to occur safely without the need of a controlling third party. By being *distributed and sustainable*, all parts of the supply chain share a responsibility for the blockchain solution and work towards a long-lasting sustainable solution, which build trust between the parties involved in the supply chain.

Since companies’ part of a supply chain often share sensitive information, blockchain contributes with a *private and secure* network for storing information. This gives companies a certainty that the information cannot be accessed by parties with malicious intent. Further to this, all information stored on the blockchain is *indelible*, ensuring all parties that the information stored on the network is authentic and that no party has tampered with it, which creates a more trustworthy information sharing network. Although information on the blockchain can be encrypted to make sure that all parties have access to the information that they need access to, there is a possibility to create a *transparent and auditable* storage and dissemination of information, while parties involved in certain transactions can easily verify trades in real time.

This correlates well with the expertise provided by the blockchain experts. Bunus (2018) talks about how blockchain can contribute with *secure information sharing*. Furthermore, it is not only secure, but as the chain of events on a blockchain are traceable, there is a potential to prove validity of origin of information. Additionally, (Bunus, 2018) says that users can be certain that data is not tampered with or altered due to the way information is shared on a blockchain internally, but also externally. An example of where this could be efficient is to showcase the legitimacy of their products or production externally. For example, a retailer part of a supply chain can prove their end consumers the authenticity of their products as well as a quality verification throughout the whole supply chain. Furthermore, blockchain can also be used to ensure everyone externally of not using child labour, providing consumers with the certainty of not supporting such businesses.

Although blockchain often is regarded as a trustless system, Christopher Ferris discusses how the implementation is not. It is crucial that companies are able to agree upon a governance model that all parts are comfortable with, for this, trust is needed. This is due to the *consensus-based and transactional* nature of blockchain, which ensures any trades occur correctly and safely, if set up correctly. Furthermore, with the technological possibility of automating transactions through smart contracts, according to Peter Bunus, there is a possibility for blockchain to increase the efficiency of a supply chain network by eliminating non-essential middlemen. Since there are a lot of inefficiencies in supply chains, with many middlemen that
do not contribute to the value or the chain itself, there is room for improvement. For example, a big part of the price of food goes into taxes, custom operations, paperwork, bureaucracy, which doesn’t contribute to the value of the product itself, but it is still there as ballast. He is hoping blockchain can provide a better solution to that, by being able to eliminate some of them.

Since blockchain offers the ability to add business rules and smart contracts onto the platform, blockchain network systems possess the ability to evolve as the supply chain matures to benefit all parties from end-to-end, which makes a blockchain network both orchestrated and flexible. This creates trust for all parties, as changes of how the blockchain network operates constantly improves to create value for the whole supply chain.

Bunus (2018) explains that you do not have to know exactly how blockchain works, but what it provides. And what it provides is, transparency, a guarantee of the immutability of the data, and help to perform transactions between parties that do not trust each other (and that is it). He says that blockchain can provide the possibility and platform to change existing business models and certain established business models.

It is challenging but important to be able to show the value that blockchain can generate for all parties involved. (Bunus, 2018) The more parties that join, the better and more qualified services can be provided.

7.1.1 How does blockchain compare to current IT-systems in information sharing?

Ferris (2018) explains that there are similarities between current, traditional IT-systems, and blockchain, but he also believes that blockchain allows for a rethink about how existing processes work and that there can be an evolution of thought once an initial implementation of blockchain has been established. Ashlin (2018) says that there is always a case for an IT-system and an application. Blockchain is an alternative that provides a trusted system of record. Beyond that, the applications built atop the blockchain can be very similar to the traditional IT-systems.

Although there are few people who would regard blockchain as traditional, it is similar to traditional IT-systems in many ways, with some additional unique capabilities. The comparison made is based on the six aspects presented in the chapter under information sharing. The six aspects are:

- **Security**
- **Accessibility**
- **Trust**
- **Commitment**
- **Reciprocity**
- **Power**

When discussing blockchain there are a few of these aspects that are argued to be improved on a blockchain protocol. When it comes to security, the theoretical framework, regarding blockchain, constantly mentions the rare contribution blockchain could provide within information sharing. For example, a term often thrown around when discussing blockchain is “immutability”. Immutability can be defined as a form of security, where transactions cannot be tampered with after they have been verified. What Cystellar have identified is that
blockchain has unique capabilities of providing security which traditional IT-systems in some aspects, lack.

When it comes to **accessibility**, a perfect example of how blockchain can change another aspect is the Walmart case. Although Walmart had the information necessary to trace the outburst of E-coli, it simply took too long to effectively prevent it. With blockchain however, the information is easily retracted and accessed.

**Trust** has previously been discussed to be an important part of information sharing. Blockchain is often regarded to as a trustless system, this is somewhat not true when using blockchain privately. When utilising blockchain on a private network, trust is extremely important when forming a governance model that everyone agrees on. (Ferris, 2018) It is however true, that blockchain can be considered a trustless system once the governance model has been established. Additionally, as stated in chapter **Fel! Hittar inte referenskälla.**, blockchain builds trust in many ways by its unique capabilities.

Although **commitment** might not be easy to evaluate since it can be both positive and negative, the way blockchain differs from traditional IT-systems is that blockchain in the current state needs a much higher commitment from the parties involved in implementing a blockchain solution than a traditional IT-system. (Haines, 2018) (Bunus, 2018) A big contributing factor to this could be that blockchain is a new technology, however, it also has to do with the decentralised layout of blockchain. (2.3.1) This could put stress on relationships in a supply chain and generate negative effects. However, it also gives parties some control over their outcome, creating an opportunity to help affect the outcome of the supply chain positively.

Current IT-systems differ in the way that they are used by companies individually, part of a bigger network. For example, all companies part of a supply chain might use the same cloud-service provider, without them being integrated directly in any way. With blockchain, everyone is on the same protocol, which creates a double-edged sword. On one hand, there is more **reciprocity** for the blockchain implementation to be successful, as everyone is part of the solution. On the other, the benefitting factor of the blockchain might not be evenly demanded, while it still takes high levels of reciprocity for the technology to function effectively. In line with what Christopher Ferris (2018) said, Blockchain has to be considered a team sport.

The last aspect, when comparing blockchain to traditional IT-systems, is **power**. Power reflects the divide of influence each party of a supply chain has. Although companies should strive to work more unanimously, as supply chain strategy has deemed most effective, most companies work individually as part of a blockchain network. What blockchain provides is a divide of power, where there is no possibility for information to be retroactively tampered with, without parties noticing. This ensures, once the governance model has been created, the safety and power divide of all parties.

### 7.1.2 What kind of data/information should blockchain be used for based on certain aspects of information sharing?

To be able to analyse and draw conclusions concerning this sub-question, the answers to the survey concerning the aspects played an important part.

**Survey answers**

A summary of the answers from the survey will be presented according to the two parts of the survey and will be presented anonymously to minimize the risk of disclosing any unofficial
information concerning these companies. In the first part the managers were asked to fill out the importance of the aspects of information sharing, on the scale from 1 being unimportant to 7 being very important, concerning the specified data sets. If they were unsure or any of the data or aspects did not apply to their business that option was available. In the second part the managers were asked to answer questions about how they share information today, which information they are least willing to share and the information they perceive their suppliers and customers are least willing to share with them.

**Part one**

In the first part the answers are presented as a mean average of the answers per aspect of information sharing for each type of data, as well as a combined mean average per aspect, on the scale from 1 to 7.

**Table 7: Summary of answers.** Inventory Information – II, Sales Data – SD, Sales Forecasting – SF, Order Information – OI, Product Ability Information – PAI, Exploitation Information of New Products – EloNP.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>II</th>
<th>SD</th>
<th>SF</th>
<th>OI</th>
<th>PAI</th>
<th>EloNP</th>
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</thead>
<tbody>
<tr>
<td>Security</td>
<td>5.7</td>
<td>5.7</td>
<td>5.8</td>
<td>5</td>
<td>5.3</td>
<td>6.8</td>
</tr>
<tr>
<td>Accessibility</td>
<td>5.7</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4.5</td>
</tr>
<tr>
<td>Trust</td>
<td>6.7</td>
<td>6.3</td>
<td>6.5</td>
<td>5.8</td>
<td>6.3</td>
<td>6.5</td>
</tr>
<tr>
<td>Commitment</td>
<td>6.3</td>
<td>6</td>
<td>6.5</td>
<td>5</td>
<td>6</td>
<td>6.5</td>
</tr>
<tr>
<td>Reciprocity</td>
<td>5.7</td>
<td>5.7</td>
<td>6</td>
<td>4.8</td>
<td>5.3</td>
<td>6</td>
</tr>
<tr>
<td>Power</td>
<td>6</td>
<td>5.7</td>
<td>5</td>
<td>4.8</td>
<td>4.7</td>
<td>5.3</td>
</tr>
</tbody>
</table>

The combined mean average is a representation of the importance of each aspect of information sharing, which can be used as a measurement of how important the respondents find that particular aspect. This average can be used to validate the chosen aspects thanks to the high value of all of the aspects.

**Part two**

In the second part the answers are presented as a combination of the respondents shared answers.

*How does your company share information with suppliers and customers today? What kind of IT-systems do you use?*

All of the managers said that their company use some kind of EDI-system (Electronic Data Interchange). Some also use some kind of supplier or customer portal, they share information via email, web sites. The manner of information sharing ranges from unofficial ways to standardized ways, such as the use of GS1-standards.

*What kind of information are you least willing to share with suppliers and customers?*

Information these managers expressed they would be least willing to disclose to partners are sensitive information about new products, sales data, cost components, prices and margins, and deals or data related to other suppliers or customers.

*What kind of information are your suppliers and customers least willing to share with you?*

The managers experience that their partners seem to be least willing to share forecasts, stock levels, campaigns related to competitor’s assortment, general business with competitors, difficulties in production, low delivery accuracy, quality issues and coming financial results.
7.2 Analysis

When discussing companies on a supply chain being beneficial from blockchain, it is important to understand two things, first off, companies in a supply chain may differ widely. Both in what their business is, but also what their goals are. Second, a benefit is something subjective and it may vary widely, depending on who you ask. Therefore, when implementing a solution that works the same way for all parties involved, more or less, it is important to identify what every part of the supply chain stands to gain from such an implementation.

The parties involved in the CyStellar case can be divided into four groups. The farmers, responsible for the produce, CyStellar themselves, the retail stores and finally, the consumers. Although the benefits for all parties involved, everyone has something beneficial to gain from the unique solution of CyStellar. Starting with the farmers, by being able to prove the origin and quality of their food, they create a good reputation about themselves, ergo generating more business. CyStellar themselves provide a unique solution where they receive a monetary compensation. The retailers, much like the farmers, are able to prove the origin of the produce to their consumers, ensuring the quality and safety of the produce. Finally, the consumers, who feel a security in the quality of the food for health reasons but also that they with certainty know that they have received what they have paid for. As ecological produce has become a more viable option for people, more and more consumers have started to doubt the origin of a lot of the “ecologically produced food” as well as all the certificates. This is therefore a working case as all parties in the supply chain are able to identify a value.

Another interesting area where blockchain has proven to be effective is in the supply chain risk management part of supply chain logistics. When operating on a global sale, some companies are exposed daily to failures in the supply chain. The reason for this is that some retailers, like Walmart, have a high number of suppliers. Whenever one of these suppliers fails, Walmart are left vulnerable and have to respond. Depending on the seriousness of the failure, Walmart receives different severity of backlash from the consumers. It also creates an effort for Walmart to, in some cases, identify the origin of the problem and if it could have been detected earlier. This is where blockchain has come to shine. Since you have the option to retrace all information stored on the blockchain network, easily, it creates an easier tool to identify the source of failure. Additionally, since the information stored on blockchain is added on to the network simultaneously as the transactions, the smart contracts could be used as a validating source to identify failures earlier, hence diminishing the bullwhip effect, simply described as not committing errors upon errors.

For a supply chain to be successful, all parties must act in the best interest of the supply chain and not for themselves. This is a much more challenging task than it appears to be. Individual companies often find themselves questioning the intentions of the other parts of the supply chain resulting in strained supply chain relationships with limited information sharing willingness or connectivity. This is what makes blockchain a unique solution with a lot of potential in supply chain logistics. Companies that look to implement their information sharing through blockchain could also gain more integrated systems externally. Therefore, by creating a unison solution for information sharing, especially since an implementation of blockchain is so costly, companies can indirectly improve their supply chain relationship and follow the strategy of supply chain logistics better without the direct intention.
Although it is hard to give any direct indications of how costly an implementation of a blockchain could be, by following the steps of logic (blockchain being a new technology with scarce expertise resources) and the comments made by the experts, it is likely to come at a substantial cost. It is therefore essential to take the words of Ashlin (2018) into account, that the journey of blockchain should start with the board members.

7.2.1 How does blockchain compare to current IT-systems in information sharing?

The six aspects, security, accessibility, commitment, trust, reciprocity and power, are all quite widely defined and are very dependent on what kind of company they describe and in what sense. Companies might have different definitions of these aspects.

For this reason, it is important to discuss what it is blockchain uniquely contributes with in information sharing and how blockchain and traditional IT-systems could complement each other. If companies start to view blockchain as a protocol on which it is possible to build traditional IT-systems on with more possibilities and if the technology matures in its development, it is only a question of time before the utilisation of blockchain will reach a mainstream adoption. Therefore, the comparisons made between blockchain and IT-systems are not in order to say which one is best it is rather to create an understanding on where blockchain proves beneficial and where companies could look for blockchain in order to improve their current information sharing network.

It is however important to emphasize to the immaturity of blockchain technology. Blockchain has not been tested extensively as IT-systems have, therefore, it difficult to compare the two directly as complete solutions. For example, the technology of blockchain has the potential to be more secure than traditional IT-systems. However, since it takes the expertise of blockchain developers to create blockchain to function immutably, there is room for error. Therefore, blockchain has the potential to store information more securely than traditional IT-systems, but does not necessarily have to in all cases.

The integration of a blockchain network in comparison to traditional IT-system is that blockchain more demanding and complicated. Since blockchain is reliant of being fully integrated throughout the supply chain to achieve many of its benefits, it creates a shared responsibility for all parties. Furthermore, the fact of blockchain being a new technology, it puts a lot of responsibility on the directors of the companies’ part of the supply chain, as they need to educate their staff in order to start using blockchain.

Furthermore, the cost aspect is interesting to consider, both in implementation and in maintenance. We currently know, based on the unanimous answer of the blockchain experts, that the implementation of blockchain is a big investment for companies to consider, bigger than IT-systems. However, it is like comparing apples and oranges. Although the implementation of blockchain is expensive, there are for some aspects no substitutes. Furthermore, the possibility of cutting cost in a supply chain through smart contracts is something that is difficult to measure. Therefore, it is at this point difficult to create business models surrounding an implementation of blockchain. However, by eliminating intermediaries, blockchain should decrease the cost, especially in verifying transactions.
7.2.2 What kind of data/information should blockchain be used for? (based on certain aspects of information sharing)

Since the answers on the survey proved that all of the information sharing aspects were important for the companies, for all of the different types of data. The kinds of data that blockchain should be used for can be correlated back to the strengths and weaknesses of the technology. As (Bunus, 2018) expressed, blockchain should be used if it can solve a problem that the company or the supply chain has.

Based on the information sharing aspects, blockchain can be considered to correlate to data that need a high level of security, accessibility and data that needs proof to be trusted. These aspects of information sharing can be seen as more tightly related to the strengths of blockchain. Since all the types of data were ranked highly by the managers on these three aspects all of these kinds of data could be considered possible to use blockchain for. Furthermore, blockchain has the possibility to provide a way of sharing information in a way that is not possible for traditional IT-systems. A perfect example of this is the Walmart case. Although Walmart could collect all the data, and did collect all the data, it was hard and time consuming for them to prove the origin and validity for the data collected.

7.3 Results

As stated previously this report compares traditional IT-systems and blockchain with the purpose of showing how the two systems could complement each other. For today’s businesses blockchain provides a unique capability that no other technology can currently replace. As all experts have expressed, the biggest obstacle will be to integrate the technology into already existing business models, meaning that it is hard to quantify the return on investment when using a blockchain solution. However, since there is a growing urge for transparency in information, security in information sharing and streamlining information sharing, businesses will learn how to utilise the technology better once it has become more mainstream and also how to evaluate the profitability of the investment.

Once companies have identified what problem they have, they should consider two things. First off, can this problem be efficiently solved by another IT-system and secondly, is the problem worth solving with blockchain. When these concerns have been addressed, companies should look at blockchain as an IT-system that can offer more secure information handling, which requires less trust, with the possibility to prove the origin of data with certainty in real time to all parties. Through the information collected in the theoretical framework and the information provided by the blockchain experts, the strengths of blockchain proves that applications could be considered for any data that is, requires, or needs to be:

- Traceable
- Easily accessible
- Proven authentic
- Stored Securely
- Immutable
- Shared in real time
- Shared to everyone part of the network

The last two can also be connected to the types of data mentioned above and could prove beneficial to the entire supply chain.
General benefits blockchain provides are transparency, guarantees of the immutability of data, and a tool to perform transactions between parties that do not have to involve trust on a daily basis. Furthermore, as the technology can be seen as disruptive it can also provide a possibility and platform to change existing business models and eliminate middlemen that do not contribute to the value of the end product. It can ultimately change the way we do business today and put pressure on existing inefficiencies in a supply chain.
8 Conclusions

In this chapter, a conclusion will be reached concerning the purpose of the thesis, which is based upon the information in the compilation of gathered information, the analysis and the results for each research question.

The goal with supply chain logistics is to maximise the added value. This is accomplished by streamlining the physical-, payment-, and information-flow erasing all inefficiencies. Information sharing is challenging for companies’ part of a supply chain and is also where blockchains’ unique characteristics consensus, traceability (provenance), immutability, finality, decentralisation and persistency can have an active role.

Blockchain within supply chain logistics can provide the ability to exchange information on pre-set terms, eliminating the need of a controlling party. Furthermore, the decentralised, immutable information sharing made possible on a blockchain allows for real-time information access for all parties on the supply chain as well as ensuring all parties of the authenticity- and origin of the data. Companies on the blockchain can therefore operate on a more transparent platform, improving trust. Along with this, blockchain can automate the information sharing between parties on a supply chain, diminishing the risk for human errors.

Having that said, companies face a number of challenges when implementing a blockchain solution. First off, companies should identify if the problem they’re looking to solve needs blockchain. Secondly, if the answer is yes, companies should identify how all parties gain value from a blockchain solution. Furthermore, blockchain is a complex technology with limited resources of expertise. Companies must therefore realise that there is a distinct difference between understanding how to use blockchain properly and how the technology of blockchain works in detail. By opting to outsource the implementation of a blockchain solution, per our recommendation, companies should not be scared off by the complex technology substantiating blockchain.

When identifying what problems companies can solve with blockchain, it is important to understand that blockchain is useful for disseminating and storing information of the four connectivity aspects of information sharing. Furthermore, companies adapting other digital technologies can, based on this research, be assured that blockchain can be used independently as well as be integrated with other technologies. What this means is that blockchain does not need any other technology to be able to operate, it needs computational power and a collaborative attitude. However, companies looking to implement other technologies can connect with blockchain to achieve synergy and provide a fully automated process of information handling and sharing.

Blockchain, with its unique characteristics, has a lot of potential and can have a big impact on many industries. However, as all new technologies, blockchain has to mature and pervade the initial hype for its true purpose to be exposed. Companies should consider blockchain as a solution to their problem, however, they shouldn’t force a blockchain solution into their supply chain.

The true potential and impact of blockchain is yet to be revealed. Once the technology has endured the Darwinian process, blockchain might make a mainstream impact on supply chain logistics.
9 Reflection

In the final chapter of this thesis a reflection about the work and contribution as well as a reflection about the findings is presented.

In an age of rapid digitalization in businesses, home products and society with a continuous globalization, it is important to keep up with the changes and at least understand the basics of the technologies that drive the change. Since the integration and connection between supply chain and blockchain is still being explored, there is a challenge to find expertise with experience in both. A technical expert of blockchain might have a challenge of understanding the logical thought process surrounding supply chain logistics, while supply chain experts might struggle understanding the technological aspects of blockchain.

This thesis is meant to close this gap by providing with information about blockchain and its applications on a basic level as well as on a more advanced level. Since blockchain is such a complex technology, companies’ part of a supply chain can use this research as a basis for their journey in exploring blockchain and have the correct mind-set in approaching a possible implementation.

Furthermore, this thesis will contribute with an easily understandable investigation about blockchain and its application in supply chains. It aims to provide a basic description of how blockchain relates to other technologies as well as to information sharing, to give the reader a foundation to stand on. Companies active in existing supply chains should be able to create an image of how blockchain could improve certain aspects of their current flow, whether it is for storing or transmitting information. This thesis will also offer an initial thought process for board members/managers part of a supply chain that consider blockchain and what steps they should follow during an implementation.

The potential with blockchain for sharing information within a supply chain is very interesting. It can have a great impact on how businesses and business models will evolve. However, as the technology is still new and constantly changing, it is difficult to be specific in exactly which benefits and challenges it will have long term. That is something that needs to be proven over time as the technology is adapted and matures and stabilises. The findings in this thesis are on a general level and to understand the potential within a certain area or industry, further research is needed on blockchains impact on specific industries.

Although it would be optimal if more high quality blockchain experts agreed on conducting interviews, the experts that agreed were experienced and knowledgeable, which is hard to find with a new technology as blockchain. A couple of the people contacted were at first glance perceived as well established blockchain experts. However, once communications or investigations developed, many were found lacklustre in their expertise with very basic understanding of blockchain. This created a scepticism to many of the so called “experts” and resulted in these experts not being part of this research. Furthermore, the information provided by the experts varied in volume, where one blockchain expert provided a vast amount of information compared to the others. Even though the blockchain experts individually provided a lot of unique information, the information was for the most coherent, especially regarding the importance of introductory parts of the implementation for companies.

The survey conducted during the research can in parts be considered as fragile. The first parts, where companies answered how important they perceive certain aspects of information
sharing, served its purpose despite only having four respondents. The purpose of the first part was to verify whether the aspects described were relevant and since all company representatives answered unanimously how important they thought each aspect was, it provided validity to the theoretical research. However, for the latter part of the survey, where companies were asked to describe what they found most challenging during information sharing, the answers were too inconsistent and too few to generate a conclusion. This combined with the lack of respondent being able to give an interview to discuss the reasoning behind the choices and the reasons for the answers on the second part resulted in the latter part being excluded from further analyses and conclusions. Although attempts were made to include more companies, the lack of time from the company representatives and the tight timeframe of the research only resulted in four responses. That being said, the information needed was acquired through literature studies, which compensated for the few answers received from the survey.

The lack of established models to use for investigating and analysing impact of new technologies within supply chains, combined with the lack of previous investigation conducted on this topic created barriers during this research. Since there are no established models to build the research upon, it created a great challenge for the authors to create a methodology. Primarily, this was considered as a weakness for the research, however, the authors soon realised that it creates the possibility to form the process, focusing on finding ways to simply illustrate the impact of new technology in a pragmatic way. New technology is often presented in a complex way, often becoming very technical, which makes it hard for the general public to grasp. This was a major concern for the authors and something that wanted to be avoided. However, by creating a specific model for the task, the methodology in this thesis created a strong and structured framework of the connection between blockchain and supply chain logistics.

The authors believe that as the blockchain technology passes through the Darwinian process, which is common for new technologies, it will be established and successful within much fewer areas than it is currently considered for. However, based on the findings of this thesis the future for the symbiosis between blockchain and supply chain looks bright, for specific application areas.
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[Accessed 3 10 2018].


Appendix

Appendix 1– Literature search

The following tables are a representation of the references used in the theoretical framework for the different terms used to explore information sharing.

<table>
<thead>
<tr>
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<th>Information sharing</th>
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<tr>
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<td>(Zaheer &amp; Trkman, 2017)</td>
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<tr>
<td>(Lambert, et al., 2005)</td>
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<tr>
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<tr>
<td>(Nath &amp; Standing, 2010)</td>
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<td>(Panahifar, et al., 2018)</td>
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<td>(Smith, et al., 2007)</td>
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<thead>
<tr>
<th>References</th>
<th>Information sharing – Willingness</th>
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<td></td>
<td>Trust</td>
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<tr>
<td>(Wu, et al., 2014)</td>
<td>x</td>
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<td>(Morgan &amp; Hunt, 1994)</td>
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</table>
Appendix 2 – Survey for supply chain information sharing

In this Survey, you as a Supply Chain specialist will conduct an evaluation of what aspects of Connectivity and Willingness you find most important for different types of information/data. The definition of each aspect is defined before the first question. If you find an aspect irrelevant or not applicable, fill in the "Not Applicable box."

If you have any questions concerning the survey or wish to add something after filling it in, feel free to send us an email.

THIS IS A STUDY CARRIED OUT BY TWO STUDENTS AT LINKÖPING UNIVERSITY LOGISTICS DEPARTMENT. ALL RESULTS WILL BE PRESENTED ANONYMOUSLY.

Name: 

Company Name: 

Job Title: 

Questions

On each question, rank the aspects on the scale from 1 to 7, where 1 is Unimportant to 7 being Critical. If any of the aspects is not applicable or you are unsure of how it affects your supply chain, fill in "Not applicable/ Not sure".

To avoid any risk of misinterpretation, the definitions of what we mean with the aspects are presented below:

Definitions:

Security – The aspect of how important network security is in sharing this information, i.e, more sensitive data requires higher security.

Accessibility – The aspect of how the technology allows all parties (pre-defined who has access to what) to access the information needed at all time.

Trust – The aspect of how important it is to trust your trading partner in a collaboration where a variety of information is shared.

Commitment – The aspect of how important it is that the parties involved in the supply chain have long-term goals and are willing to sacrifice short-term losses for long-term wins.

Reciprocity - The aspect means that one partner will be willing to share information with another as long as that partner provides information of the same value in return.

Power - Power refers to the relative dependence between exchange members, where power gained by one member can influence the decisions and behaviour of other members.

Part 1

Inventory Stocklevel Information

Inventory information is information in regard to the stock and is considered one of the most important aspects of information sharing in a Supply Chain. An example of an efficient solution for inventory information is VMI.
Sales data

Sales data information is information showcasing how well different products have sold and is important to identify different trends in popularity and consumer behavior as it shows the true customer demand.

Order information/Traceable information

Order information is also regarded to as Traceable information. In order to see where products currently are in the supply chain, as well as where they have been, it is important that every part of the Supply Chain share information regarding the product. This is important to potentially identify a bottleneck in the Supply Chain, as well as if quality doesn’t match the pre-set standard.
Commitment  |  |  |  |  |  |  |  |  | N/A
Reciprocity |  |  |  |  |  |  |  |  | N/A
Power       |  |  |  |  |  |  |  |  | N/A

Any aspect you wish to add?

**Product Ability Information**

Product ability information is information that may assist the deceleration of the possible shortage gaming behaviour and potentially avoiding the Bullwhip Effect.

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Any aspect you wish to add?

**Exploitation information of New Products**

Exploitation information of New Products is information shared to receive goods from the supplier in time. This is considered as the more sensitive information to share as companies are frightened to be at a disadvantage for sharing this kind of information.

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Any aspect you wish to add?

**Part 2**

How does your company share information with suppliers and customers today? What kind of IT-systems do you use?

What kind of information are you least willing to share with suppliers and customers?

What kind of information are your suppliers and customers least willing to share with you?

**Further Comments**

Do you wish to add something about information sharing in your supply chain?
Blockchain can be broken down into attributes which can be directly derived from the key characteristics. Information sharing has been broken down into connectivity and willingness, and further into the chosen aspects of information sharing. Combined, the attributes of blockchain and the aspects of information sharing led to the conclusions concerning the use of blockchain for information sharing, as presented in the pictures below.

These connections between blockchain and information sharing can be related to the first two steps of the implementation model presented in section 6.3, and are important to understand prior to the adaption of the blockchain protocol.