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Forming the future digitalized supply chain through the use of blockchain technology

An exploratory study of blockchain's effect on the supply chain

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Forma den framtida digitaliserade värdekedjan genom användandet av blockchain

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Abstract

Today there is a strive towards a change in the business climate where openness and collaboration are two key words shaping the industries. One way of facilitating the shift is with digitalization. With digitalization more information can be collected quicker with better accuracy and correctness. With digitalization the ability to obtain more information and knowledge increases and digitalization then becomes a way of developing processes that were designed for a previous business climate. The digitalization is reaching a level where it needs to be spread outside the company borders in order for companies to take the next step in business efficiency. A way to facilitate this is with new innovative technology that can satisfy the need in the transformation thus security and uniformity become two important aspects in the matter. It has to be secure and easy to obtain the information and knowledge outside of the company borders. Blockchain technology has been praised as a secure and trustable way of exchanging information and clearly has potential of becoming a new game changer for industries. Blockchain has been identified to have potential in the usage areas Transaction, Tracking and Transparency. The technology is not yet mature enough to be used in correlation with its potential in research. Mostly security and process time has to be improved before implementation within manufacturing industry. The manufacturing industry and the supply chain will benefit from a higher collaboration, communication, sharing and trust, which digitalization facilitates. The new technology, which facilitates digitalization, will make it possible to cut through the complexity and collect information from where it before has been blind spots. Blockchain technology seems to be the tool that fills the gap in the chain to achieve more knowledge and information, which can shape the future supply chain.

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Sammanfattning

Idag strävas det efter en förändring i företagsklimatet där öppenhet och samarbete är två nyckelord som formar industrin. Ett sätt att underlätta förändringen är med digitalisering. Med digitalisering kan mer information samlas snabbare med bättre noggrannhet och korrekthet. Med digitalisering ökar möjligheten att få mer information och kunskap och digitalisering blir ett sätt att utveckla processer som utformades för ett tidigare företagsklimat. Digitaliseringen når en nivå där den måste spridas utanför företagets gränser för att företagen ska kunna ta nästa steg i utvecklingen. Ett sätt att underlätta detta på är med ny innovativ teknologi som kan tillgodose behovet och säkerhet och enhetlighet blir två viktiga aspekter i frågan. Det måste vara säkert och lätt att få information och kunskap från utanför företagets gränser. Blockchain har blivit hyllat som ett säkert och pålitligt sätt att utbyta information och har tydligt potential att bli ett verktyg för industrier. Blockchain har identifierats att ha potential i användningsområdena Transaktion, Spårning och Transparens. Tekniken är ännu inte mogen nog för att användas i samband med den potential som lyfts i forskning. För det mesta måste säkerhets- och processtid förbättras innan en implementering inom tillverkningsindustrin. Tillverkningsindustrin och värdekedjan kommer att dra nytta av ett högre samarbete, mer kommunikation, delning och tillit, vilket digitalisering underlättar. Den nya tekniken, som underlättar digitalisering, kommer att göra det möjligt att skära igenom komplexiteten och samla in information från där det tidigare varit svårt. Blockchain verkar vara det verktyg som fyller glappet i kedjan för att uppnå mer kunskap och information som sedan kan forma den framtida värdekedjan.

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1. Introduction

Introduction chapter to master thesis work in Industrial Engineering and Management at Royal Institute of Technology.

1.1 Background

The digitalization of society and industries is continuously growing and is changing the business climate, resulting in new companies profiting from a digital mindset. However it is also the future for existing companies. The ability to make processes today more digital as well as making physical assets digital is what will contribute to driving value. Furthermore it can be a necessity for developing in to a competitive company. The key driver is the increased efficiency (Bohsali et al. 2016; Buchanan, 2016). Digitalization is not done easily and needs to be handled in a strategic manner as well as collaboratively. It is important to look at the need for digitalization from a higher perspective to identify the processes and areas that could benefit the most. Furthermore it is vital to collaborate across the supply chain and embracing openness. In order to achieve change it is necessary to have the right, innovative and digitalizing technology (Bohsali et al. 2016).

One of the most promising technologies for digitalization is blockchain. Blockchain is interesting investors in a way not seen at any other emerging technology and is getting more and more attention (Milani et al. 2016).

The blockchain revolution began with Bitcoin in 2009. People were skeptic to the digital currency but those who had more knowledge about it saw the technology behind it, blockchain (Saeed, 2016; Evans, 2016; Furlonger & Valdes, 2017). It has been described as the new web or the new Internet. It is a decentralized system that would enable a peer-to-peer connection that Internet cannot do today. For example if one wants to send money to someone else one still need a bank to complete this transfer, if blockchain is fully implemented it has the possibility to eliminate the banks involvement in that kind of money transfer. This would revolutionize the society, as we know it, similar to what Internet did back in the day (Tapscott et al. 2016). Blockchain is a decentralized system that is built up by nodes in a network. The nodes in the network communicates with each other all the time, allowing information to be stored about everything with no possibility to tamper with it (Tapscott et al. 2016). The chain of nodes communicates internally to always validate information that is put in. An example of a use case is to track physical parts as well as assets. That would mean that a large manufacturer could track every single component within the supply chain together with documentation and assets. This creates a completely new way of business and opportunities (O'Connor, 2016).

These opportunities, though briefly exemplified above, are getting more and more attention. The investments within research and startups about blockchain are increasing rapidly and during the last nine months of 2016 $1.4 billion were invested (Kennedy, 2016). The business value of blockchain technology is close to zero at the moment, however forecasted to be worth over $3 trillion by 2030 (Furlonger & Valdes, 2017). There are now several communities that are trying to create a cross-industry collaboration about blockchain and its potential. One of them is Hyperledger, they have some of the biggest companies in the world as members and one of them is Airbus, a leading aircraft manufacturer. This is interesting because the aerospace industry is a complex and technologically dependent industry. The industry is therefore keen to be in front regarding technology and is so this time as well (Warner, 2016).

Looking back at the tracking of assets example this requires a communication system along the whole supply chain. This is where blockchain comes in. This new communication system allows more exchange of information through a more trusting way and will potentially change the business environment through digitalization.

1.2 Problematization

The digitalization experienced in society does not seem to halt, merely it is the start of a new revolution. There is therefore a need to investigate what could contribute to companies' continuation of competitiveness through investigating digitalization's effect on a supply chain. Therefore it is needed to investigate what technology that can contribute to the digitalization as well as taking a stand in how, more concrete, the digitalization could be beneficial. It is further a need to see how this technology could benefit to the digitalization (Bohsali et al. 2016).

Blockchain technology appears to be the future but it could nonetheless be a disruptive technology that will need maturity and research before being accepted by the great mass and especially companies that can potentially suffer a great setback if just jumping on the "train" and being ready too soon. At the same time there are countless of examples of companies that missed the "train" and went as bad as bankrupt, an example is the former giant Kodak (Jee, 2016). It is about timing and early research before deciding about when to jump (Adner & Kapoor, 2016).

Even though the potential seems huge to the enthusiasts there is still much research to do to find out what the use cases are. The technology is new and only briefly tested in certain areas. There is therefore a need to identify possibilities for companies as Airbus and to what that could lead. To be stated is that Airbus is used as a company of reference in order to narrow down the research and make it more industry relevant. Companies such as Airbus differs from the society's need and require thorough and self

conducted research before obtaining usefulness from blockchain. The area is not yet explored enough to connect the dots on what new doors that could open if blockchain is implemented in a certain use case.

As a conclusion the problematization is threefold in terms of why more research is needed; firstly the technology have potential which few seem to deny but it is still in an early stage and there is research needed for companies in order to lead or at least follow the new technology's development. Secondly research is needed due to figuring out what the technology can mean for the specific company, hence what usage areas there are for blockchain over the supply chain. Most of the focus has been in the financial sector and not yet in manufacturing and its effect on the supply chain. Thirdly, the overall problematization should not be forgotten, which is that there is need for a digitalization and research is needed in new technology to see if it can benefit companies towards digitalization. To be added that even though digitalization is the overall problematization blockchain is the focus of this report.

1.3 Purpose

This report aims to investigate how the use of blockchain will contribute to a digitalization of the supply chain for large manufacturing companies with complex products and a complex supply chain. To lay ground for future research by becoming a guide lining report for future research and for R&D at companies interested in the use of blockchain by presenting usage areas and important aspects.

1.4 Research question

The **research question** in this report will be the following:

How will usage of blockchain technology contribute to digitalization of the supply chain for complex manufacturing companies?

Sub questions:

- What are the drivers behind digitalization that makes new technology desirable along a supply chain?
- What practical use cases for blockchain come for a manufacturing company within a supply chain?

1.5 Contribution

Most importantly this report contributes with research about blockchain as a way of digitalizing the supply chain. It gives light to a new way of looking at blockchain in manufacturing. It furthermore gives deep insight about the drivers behind digitalization, how blockchain contributes to this and proving areas of usefulness.

This research will contribute not only to the companies in target (manufacturing companies with complex products), as is an obvious when the question is answered thoroughly, but it will also contribute to deeper understanding for the dependent industries. The research will present the importance of digitalization for a supply chain, it will further show that blockchain is a promising technology in order to achieve digitalization and it will show where and how blockchain could be used. The contribution therefore is the connection of these areas while still presenting a research that has a reality anchoring in terms of risks about new technology.

The future generalist researcher will obtain a springboard for obtaining results, which this research mainly wants to contribute to, and will have a report to base future research decisions on in terms of the future use of blockchain technology and how it contributes to digitalization (Schmenner et al. 2009). This is due to the knowledge about the most promising usage of blockchain, as a result of this research. Further by laying ground for future citations and basic contribution it will contribute to a collection of research of the topic in order to, in the future, be a way of hedging for bias (Boyer & Swink, 2008).

The report further contributes through its structure, as stated it is contributing for future research by becoming a report to base future research on. The structure of the report is designed to function for all levels of future research, this by creating distinct chapters leading to excludable chapters or sections depending on previous knowledge in the area.

Much of the contribution in more vague terms is derived from the exploratory methodology, which is the factor behind a lot of the contribution. For example it brings new information, insights and knowledge in to an area that is not yet very researched. It therefore gives a direction for future research.

1.6 Delimitations

The scope of this research will focus on usage of blockchain in regard of large and complex manufacturing companies. This means that all other companies will not be a target group for this research thus sometimes used as examples in order to get results. The frontier of blockchain technology, finance sector, will be used when necessary. The amount of information regarding digitalization, supply chain and blockchain is

extensive, hence is to broad to cover therefore the research will mostly focus on research where these areas are merged. The scope will only include parts of the supply chain with focus on how to digitalize. That is because there is no aim to investigate every possible digitalization area. The supply chain will be considered in a general way in order to achieve contribution on a greater scale and also because the research does not aim to investigate detailed implementation of the new technology.

Furthermore the result can only affirmatively be seen as applicable for the initial target companies without further research. The focus regarding the effects of the results will be on a general level and in terms of possibilities, thus not in calculated absolute values.

The interviews will be done with manufacturing and banking experts and will not cover other possible minor actors, as for example regulators of standards or insurance companies. The timespan also makes the number of interviewees chosen to five in total, this in order to get the most out of every interview.

Regarding literature delimitations there is usually an issue with old published material when researching new technology. However in this case the technology is that new that all sources must be seen as having no age delimitation. However the delimitation then comes regarding the usage focus of the technology, everything to close to crypto currencies will be foreseen. The research is also delimited in the sense that it does not aim to research the technical foundations of the technology.

2. Method

This report is a research paper focusing on the type of company as Airbus. That type of companies is in terms of few, complex products manufactured each year and complex supply chains.

2.1 Research design

In this chapter a presentation is given of the structure and the general methodology concepts used.

2.1.1 General methodology concepts

This research has an exploratory approach. It, as stated, has the purpose of being a guideline for future research. It therefore had an approach of not aiming for only conclusive answers. The questions were designed in a way to be exploratory and the discussion was not focused on providing final proof. The methodology gave the author flexibility within the research as well as tackling the problem with an open mind (Dudovskiy). The author has however worked in a structural way and therefore influences of a deductive approach can be seen. The author spent a vast amount of time on initially reading and screening literature. Furthermore in order to drive the research forward hypotheses were created after sections where focus changes or where extraordinary findings have been presented (Blomkvist & Hallin, 2015). The hypotheses were not explicitly formulated and functioned more as a mind tool, however it does not minimize the effect it has had on the logical thread in the research. Even though deductive methodology is a smaller part of the research than the exploratory approach the author was well aware that a deductive approach tends to seem biased towards facts that supports the means of the research, by realizing that the researcher worked in order to avoid it (Barratt et al. 2011). The work put down to avoid biased is mainly explained in chapter 2.2.

This report is throughout underpinned with observations or examples in order to emphasize the point of the theory as well as making it more convincing. However in order to make the theory less biased, risks and criticism against the main topic was done (Maanen et al. 2007). To exemplify, the research focus on innovation and therefore criticism was brought up regarding risks as well as questioning the actual originality of its functions. Furthermore this research was done as a thesis, the lack of experience meant less of a lock in effect in methodology; methodology is stated to not be knowledge. That meant that the report tended to focus more on creativity and understanding when forming the research and its outcome. Furthermore the fact that it was limited time and experience meant that the researcher was not aiming to develop new theories or breath taking findings. However the author means that this was a

positive effect and has therefore instead focused on building a ground for future research through presenting more facts that support current and future theories, all that aligned with Schmenner et al. (2009). Furthermore the purpose is to be a guide lining report for future researchers and therefore it is consciously informative in the descriptions of the technology and the usage areas.

The researcher have had a target company in mind in order to obtain a good generality level so that it becomes applicable to more companies, but especially applicable to all companies in the same position, size and product complexity wise. Interviews are a tool to obtain this level. The interviews can be viewed as the last zoom towards the industry and adding value to a new area where literature did not reach all the way. To conclude, a general research with a target company in mind to steer the research.

2.1.2 Structure

The topic is derived from interest in new technology, digitalization and supply chain. These are therefore the areas of research in line with (MITLibraries, 2015), which states that interest lead to better research.

The structured presentation below is to clarify the research design as well as more clearly present the logical thread of the research. It is done elaborately since it is important to understand the logic behind a research less strictly following an approach.

Research Design:

1. Investigating a more efficient business through digitalization
2. Investigating the blockchain and its key functions
3. Investigating the need and the functionalities of blockchain within manufacturing
4. Emphasizing on the immaturity of blockchain through understanding new technology impacts and issues
5. Researching proposed usage areas derived from key functions and functionalities
6. Discussing the usage areas and the use of blockchain to obtain higher resource efficiency through digitalization

More elaborated:

1. This part focuses on what possibilities that are born from digitalization. This by understanding the drivers behind digitalization. This part of the research was done through scanning current research in the area, identifying trends and examples as well as general importance.

2. The second part becomes vital due to the identification of that new innovative technology is necessary for a higher digitalization. The part therefore focuses on understanding the new technology and what functions that is innovative and potentially value bringing. This part was focusing on academia and further at company and governmental reports regarding the topic.

3. When identifying and understanding the functions of the technology it was logical for the author to understand what the need in the industry was for it. The focus on manufacturing with complex supply chains made the selection of Product Lifecycle Management (PLM) and Supply Chain Management (SCM) functionalities reasonable. It is from a product information perspective and PLM and SCM are highly relevant. Chose two major areas, however superficially, in order to get spread in desired functionalities.

4. Blockchain is hyped and therefore it is necessary for argumentation of logic, as well as validity and reliability, in similarities to disruptiveness as well as realizing risks with new technology. By identifying characteristics in the sense of new technology also gives a good insight in order to compare the technology to previously hyped technologies.

5. When having identified functions of blockchain and functionalities contributing to manufacturing there is a need to see actual usage areas in order to verify the potential of blockchain.

6. Discussion was here conducted to discuss the usage areas as a way for blockchain to digitalize, hence obtain higher resource efficiency, as well as discussing new technology.

2.2 Information collection and critic

This chapter present the sources used in the report, except these in the initial scanning. Recorded interviews and recorded presentations were used as inspiration and basic understanding.

Literature and interviews play different but vital roles for the paper. The literature functions as a source for more general and broad information. It has the advantage of being obtained easier than interviews. This is true time wise but also that, in this case where the focus is new technology much developed by companies, it is hard to collect broad and accessible information from interviews. Hence the literature gives the report information that is necessary for evolving the ongoing research. It functions as a good information source when areas are combined, as digitalization, blockchain and supply chain where interviews would have had to be done extensively in order to give the same

amount of information. Furthermore the literature creates a better environment for finding unsolved ends for further research and findings. To add and conclude, the use of literature is essential for obtaining a lot of information and in order to do the problematization researchable (Blomkvist & Hallin, 2015).

The interviews however functions as the reality and industrial view of the research. The literature's limitation is the tendency to create a hype for blockchain. Therefore the interviews are able to fill the gap between literature and reality, which is a key point of this research as well as creating a deepened understanding (Blomkvist & Hallin, 2015). It furthermore functions as confirmation or disapproval of the more specific findings done in literature part of the research. This is essential for discussion and conclusions because the interviews are the checkpoint for the creation of final analysis (Blomkvist & Hallin, 2015).

In conclusion, the literature is essential for obtaining the bulk of information while the interviews create a more industrial and specific view of the research. The research can then be classified as a literature based research strengthened by interviews.

2.2.1 Literature

This report is based on published material with an academic acceptable level, as reports, journals, articles and books. These are the main source of information. However use of company reports, magazine articles and web articles are exceeding the normal amount for a thesis report due to the immaturity and fast development of the topic area. This is because the author believes that in order to deliver a report of the most current value only published academic works will create a time delay, since it is a fast growing technology. There are companies with high reputation doing research within the area and their publications and information are to be regarded as useful sources for this research.

In regard of the non-academic sources: Companies take help from and take trust in consulting firms for investigating blockchain's impact, therefore these company reports and articles should be reviewed as created by experts in the field. The web based articles used are never used as a single source where it can have high impact on the results, however highly regarded journals or industry specific content were used since they often contain interviews with field experts or other relevant information. For example as the Interviewee 2 states: "We work a lot with consulting firms for research because they can be trusted when they write papers. They also have a way of writing which is easier to understand." This statement is not used as proof but more as an indication of what is used in research at companies. In addition all this information were reviewed with high caution in order to avoid bias, use of fact lacking information and other non-reliable information. In both academic and especially non-academic sources

the checklist presented by Blomkvist & Hallin (2015) p. 118 was used to value the sources critically.

One limit regarding blockchain is that in this report blockchain is used as the word for all the blockchains on the market. The same goes for much of the literature research, therefore the research might not represent one product but rather a wish for a future product.

The research used these keywords:

Keywords: Digitalization, Digital Business, Industrial Revolution, Blockchain Technology, Disruptive Technology, Smart Contract, Ledger, Digital Signature, Product Lifecycle Management, ERP systems, Supply Chain Management, Transaction, Tracking and Transparency

The keywords have been used as search terms in different databases. Primarily at Google Scholar, Google, KTH Diva and KTHB Primo. The keywords have been created in an iterative process where scanning and brainstorming created initial keywords. These led to a way in to the research area. Researching with initial keywords led to finding of more keywords that were of key interest for this research. This was an ongoing process through out the literature review. Furthermore the researcher has used top cited sources to find other valuable sources by using their references when interesting. This has led to a broader as well as deeper possibility of finding information. This way of researching has made it easier to overcome the barriers where there are several words or terms for the same thing, hence leading to less missed information.

2.2.2 Interviews

Interviews were conducted with three different focuses. Furthermore the interviews were done with a semi-structured approach with unstructured influence (Blomkvist & Hallin, 2015). See Appendix for full interview guide. In order to assure correct information and to be able to instead focus on listening, thus contributing to driving the interviews forward, a phone has been used to record in consent with the interviewees (Voss et al. 2002).

In all contacts made for interviews the first contacts have been with a senior person in order to increase accessibility in to organizations, this has been a key for obtaining the information about new technology (Voss et al. 2002).

The first one was with individuals doing research about blockchain for an industrial use, more specifically a manufacturing company use. This was to understand what is to be

done and what technological potential there is. It was also in order to understand the drive behind the research. This was done with:

Interviewee 1, **Blockchain Consultant, Large Manufacturing Company**
Interviewee 2, **Senior Manager, Engineering IT research lab, Large Manufacturing Company**

The second focus was to get information from a more senior point of view. That was in order to get information from sources that had more experience and a better understanding of the whole supply chain. The interview was done as a focus group where both interviewees participated. A focus group method was chosen to encourage a more brainstorming environment, in order to get new areas to discuss than the ones initially written down (Blomkvist & Hallin, 2015). The topics were written down and the author giving a presentation about blockchain, in order to give the right ground for a discussion, initiated the meeting. The participants were:

Interviewee 3, **Project Manager Logistics, Large Manufacturing Company.**
Interviewee 4, **Vice President Manufacturing & Supply chain, Large Manufacturing Company.**

The third focus was to get information from a banking perspective. There were mainly two points of interest for this, the first one being that the finance industry have been doing research about this longer than most other industries. The second being that banks are frequently discussed in research even for supply chain benefits. Contact was made through contacting a senior manager in order to be pointed to the most suitable employee for answering the questions regarding the research (Voss et al. 2002).

Interviewee 5, **Blockchain Project Manager, Large Bank**

Few in the world have full knowledge about blockchain and even fewer have knowledge about blockchain within manufacturing. That lead to a small sample size in interviews. However the purpose is not to get a large sample size, but rather expert's opinions, the number of interviews are limited to five and therefore it becomes a limit of diversity in opinion. The quality of the interviews should however not be questioned when diversity is mentioned as a limitation.

2.3 Validity & Reliability

Validity

Limits came from the experience of the author in terms of previous research work, limited training in academia relevance training, such as scholars get, further contributed to knowledge gaps (Maanen et al. 2007). However in order to guarantee high validity great focus was on this topic. This present it self throughout the work through the coherence of methods accepted by the academic world. For example there is multiple sources used where one source could have filled the gap solely, in order to create higher validity (Voss et al. 2002). To further achieve high validity time was spend on one important factor, which is that the technology has been mostly developed within finance and therefore research will be conducted with high concern for the analysis drawn when converting to the manufacturing industry. However in the extent possible, research regarding manufacturing has been used in order to be in line with the purpose of the research.

Reliability

The research mostly uses personnel with manufacturing knowledge in order to achieve reliability, one source from banking was used due to the fact that it is more reliable regarding the transaction usage area. As an interview method the use of semi-structured interviews was the main focus and due to the nature of this research also a key aspect in terms of reliability (Blomkvist & Hallin, 2015). The author was, in order to conduct the most reliable interviews, well prepared by conducting interviews after understanding the technology and the direction of the research. Furthermore the interview questions were written in a way so that it tend to be necessary with more elaborative answers, this in order to put less of the authors possible bias in to the questions.

Earlier described is that the use of the checklist function to generally try to provide source criticism, however it furthermore functions as a tool to question the material in order to obtain higher reliability throughout the research (Blomkvist & Hallin, 2015). The reasoning behind the use of sources has also been in focus in order to achieve higher reliability, therefore the majority of the sources are no older than 2010. Furthermore the sources, which were discussed under source criticism, have been given a lot of thought regarding the use of academic and non-academic sources.

2.4 Ethics

This report has taken ethical matters in to account, especially regarding the interviews and the interviewees. The interviewees' requests have been taken in to consideration and the author when asked has signed confidentiality agreements. In line with that the text regarding potentially confident information has been sent for approval before being shared with supervisor or other party. As noticed are all interviewees' referred to anonymously and titles have been altered to secure that their title cannot be searched for. Furthermore regarding the anonymity the names of the companies are not revealed. In conclusion regarding the interviews, all interviewees has been aware of what purpose the interview are for and also that the report will be public.

Information given to the author outside of an agreed interview situation by anyone has never been taken in to account to use. This includes documents, reports and spoken information. Lastly the report has through Royal Institute of Technology been screened for plagiarism and is accepted.

3. Literature Review

The report is exploratory with a certain logical thread that the author used to drive the research forward. To fully absorb the research the author recommends reviewing the following logical thread description: Firstly lets do a reminder to the problematization, the overall problematization is that research is needed about new technology to see how it can benefit companies towards digitalization. So the logical initiation is to review digitalization both in general and in the supply chain. Then it becomes necessary to identify how technology fits in to the digitalization of a supply chain. Following is the understanding of the technology, blockchain, and its functions. However a promising technology will not become a global solution and therefore it is necessary to understand what functionalities that the technology can contribute with towards a supply chain. Finally, showing a realistic mindset regarding new technology's impact since technology rarely is a quick fixer to all problems.

3.1 Digitalization

This research's initial focus is digitalization. When researching the subject it has shown confusion between the use of the words digitization and digitalization, therefore the words will be defined here:

The definition of digitization is converting analog information such as documents, books, pictures and such in to a digital version. More precisely converting them in to bits (Rajeshkannan et al. 2011). The definition of digitalization is to increase the use of digital technology in the processes at an entity. However the words digitization and digitalization is today used interchangeably in research and papers (Kreiss & Brennen, 2014). This report will cover both areas but will for the ease of reader and author use the word digitalization due to it having a more overall view of moving towards a digital business. To use Gartner's (Gartner) definition, which is more company relevant than the previous one, digitalization is to provide new revenue and value opportunities by changing the business model towards a digital one through the use of digital technology. Simply becoming more digital. In the same way that Gartner has identified the issue McKinsey (Dörner & Edelman, 2015) has seen the need for making the definitions more concrete and have therefore developed three areas for making it more relevant to recipients. The three areas are: creating value at new frontiers, creating value in core business and building foundational digital capabilities. It is important to give this report a direction in the digitalization in order to achieve higher relevance and making it clearer. This report will focus mostly on the latter one, which means to be digital in order to be quick and agile. It is about digitalizing to have more information to make more rapid and better decisions. Fundamentally developing a digital mindset to be better informed in general, throughout the whole company. The second one is fundamentally about digitalize in order to deliver better customer value. Some focus will be on this

track since it is hard to completely separate from this when researching a supply chain. It will not focus on customer interactions more then that a digitalization of the supply chain could increase the efficiency in production resulting in customer satisfaction.

3.1.1 Digital mindset

That we live in a world of digitalization is not new to anyone, however that does not mean that it comes naturally to businesses. Al-Debei et al. (2008) even states that adaption is critical for survival and success, this is done through obtaining new levels of knowledge and information in an era where technology change in an increasing complexity. The report further points out that to maintain and obtain a competitive position it needs to be an ability to, through still remaining a high quality business, respond to changes through new business models. In the world of traditional business, business strategy and business processes were static, simple and aligned. Where digital business is evolving a gap has been created between the strategy and the processes. The need for a more digitalized business model is therefore on the rise in a more and more rapidly changing and complex business environment. This is further confirmed by Scheibenreif (2016) which states that the digital business is what can make companies overstep current barriers in the traditional industry in order to create new value. It is technology that has changed the traditional way of working. This area has been heavily researched, to see the technology's alignment to the strategy and model. However the interesting is then to see the technology development's role in the changes of traditional business and through global connectivity enhancing information and communication (Bharadwaj et al. 2013).

Bharadwaj et al. (2013) further acknowledges the digital development by stating that it is stretching towards sharing the digital assets with other companies. Than one way to achieve a higher level of digitalization is through scaling out of the own company. However the level of digitalization is in itself not directly correlated to development. The interesting is what can be done with it. Since 25 years it has been shown that the technology itself is not what drives value but instead the increased access to information. Which is mainly what Enterprise Resource Planning systems (ERPs) are designed for. However, what is often overlooked in the current systems is the importance of an end-to-end visibility in order to fully enhance the value creation of digitalization.

3.1.2 Digitalization trends

Al-Debei et al. (2008) mention that there is a new industrial revolution, which is further proven by Zhou (2013) that states that developed countries are aiming to revitalize the industrial industry and foremost advanced manufacturing. Economic development is driven by the reliance on technology, which means that the focus in the developed countries is adaption of the latest technologies. Studies show that the U.S. had their manufacturing advantage through advanced technology and IT. However from now on this advantage must be used for digitalization in order to achieve changes in the manufacturing to maintain advantage and develop the industry (Zhou, 2013). In the report of Buchanan (2016) it is further pointed out that the digitalization is a way to achieve changes and maintain advantage. It states that analyses show that companies struggle with cost optimization, the analyses show that the struggle is due to the outdated strategic thinking. There is a need to follow the trend of adapting strategies aligned to a digital era. Analyses further show that the new era means that cost optimization has to be done simultaneously to being prepared for coming digital inventions. The key areas for achieving cost optimization can be summarized as digitalizing physical assets and processes using IT while at the same time use the IT do drive cost reductions. The previous cost cutting strategies and cost strategies are now outdated due to the digitalization. To exemplify to make it more tangible, using digitalization through innovative technology that can give more automated information, which today is done by site inspections, can reduce the field service costs of a manufacturing company by 50% (Buchanan, 2016).

Another trend is the development of management processes. It is a part of the digitalization where the key content is to collect information from the whole to supply chain and connect it with internal information in order to obtain a digitalized production system. The goal is to have an overall view, through more information, in order to make quicker and more agile decisions. This is valuable in the sense of product development and market response. Another goal is to achieve optimization of the production and the life cycle of a product, which is done through more information easily obtained in a more concentrated form (Zhou, 2013).

The trends brought up by Buchanan (2016) and Zhou (2013) might not be completely new or revolutionizing, however they are being researched from a development of digitalization point of view and is getting attention in the industry. The Chief Executive Officer of Siemens explains it as a digitalization of the industry, where more information can be collected and then analyzed. It will be value driving and it is the future of Siemens (Bohsali et al. 2016).

3.1.3 Digitalizing the supply chain

One definition of Supply Chain Management (SCM) is the management of flows within a company in terms of products, services, and information through the whole supply chain. A key for this is the ability to control processes in an environment with rising customer demand in terms of lead times, quality and reliability. In order to maintain and obtain customer satisfaction a key is more collaboration and communication. In order to develop these areas new technology is vital and especially technology focused on information sharing and communication. It is in some areas known as sharing economy and has gained in importance exemplified through Über and AirBnB (Polacco, 2016). Al-Debei et al. (2008) share and enhances the importance of new technology. The report stresses that new technology will lead to a needed digitalization of the manufacturing industry and the whole business model can then evolve. This is the most central part of the new industrial revolution.

The key takeaway is the importance that new technology plays in order to achieve a higher collaboration and communication to, in the end, satisfy customers and develop the business.

It is increasingly important to be able to coordinate the supply chain. Through truly collaborating, to achieve a more agile supply chain, competitive advantage can be obtained. This is in order to respond quickly but also to develop the future products (Bharadwaj et al. 2013). In other words, in order to continue to improve the operations and develop the business it is important to improve the collaboration, communication, sharing and trust along the supply chain (Polacco, 2016). This is further shown by the statement that the important new value trends for todays economy is sharing, trust and borrowing (Howard, 2016). The enabler of these areas of growing importance is technology (Polacco, 2016).

It can sometimes seem as digitalization is something new but what should not be forgotten is that digitalization is not absent today. Polacco (2016) raises an important remark that today there are systems, ERPs, that facilitate the information sharing in order to try to achieve a real time information about processes to improve the operations. It has greatly enhanced the efficiency through connectivity and optimization of the supply chain. ERP has undoubtedly serviced corporations. However they are expensive and difficult to use. It is also today a problem with data security that means issues for corporations.

3.1.4 Risks of adapting new technology

Adapting to new technology and trying to transform in to a more digitalized supply chain is not risk free. The risk increases when it crosses the border of a company making it an intercompany digitalization, which is the case in a supply chain digitalization as mentioned earlier that Bharadwaj et al. (2013) stated. Xue et al. (2013) concretize it by explaining that firstly it is the risk of implementing new technology, which is caused by uncertainty when going from a functioning system to a potentially better system. That increase is due to the control becoming partially outside of the company's hands due to intercompany implementation. The second major risk is the uncertainty of what will happen to the relations within the supply chain when new technology hopefully opens new possibilities, called transactional risk. These two risks are not to be taken lightly and have during the history scared companies from adoption. A third but less structured and researched risk is the different cultural or national readiness for a digitalization, for example across a supply chain. Buchanan (2016) explains it in a more generalized way, which is that there is a risk that new technology seem to be hyped and marketed as an overall solution, however the more overall solution the more customization for the implementing company.

It is further possible to ease the risk when implementing systems by keeping internal systems modular from the intercompany system. To keep a modular approach to a digitalized supply chain increases the flexibility and reduces risk. Being able to isolate from system failures in the digitalized supply chain systems reduces risk. Increased flexibility comes from being less dependent on a whole supply chain as well as being able to quicker adapt to technological changes. Furthermore global standards lower the risk with new technology, however not for the second risk where there are concerns of what the other actors in the supply chain will do with more information and more powerful technology. To be noted is that risk theories state that being aware of risk lowers risk of taking actions that can be harmful. To conclude, keeping above mentioned in mind reduces risk and the risks then instead migrate towards transactional risks. For tackling this risk it is important to involve managers and other knowledgeable personnel from the IT division, they have more knowledge about the area and can therefore provide helpful information of what the risks might be (Xue et al. 2013).

3.1.5 Technological trends

To recap there is a need for more collaboration, communication, sharing and trust in order to develop business. To do that there is a need for a digitalization since it is the core of the new industrial revolution and then there is need for technology. Furthermore it is important to notice that it is the technology that enhances the access to knowledge and information, which is the value driver of digitalization.

What are the possible technological trends that through digitalization can satisfy more collaboration, communication, sharing and trust? Due to a report by Gartner (Cearley et al. 2016), which is the leading IT research and advisory company in the world, blockchain is selected as one of the top ten technological trends for 2017. Blockchain stands out in terms of its connection to collaboration, communication, sharing and trust.

Blockchain:
It is a distributed ledger that is shared between a network, which is not possible to tamper with and therefore making it a trusted ledger. It is trusted also because it allows time stamping of added information. It uses a peer-to-peer network with algorithms for assurance and trust (Cearley et al. 2016). Pilkington (2015) uses a simpler definition, that blockchain is a secure public ledger that is shared over the Internet. Blockchain is a collection of different ledgers on the market. Moreover the use of the word ledger do not correlate with a static sheet of information, it can be programmed to be very dynamic and include functions such as automated executed contracts, which is believed to lead the way for programmable economy. The immaturity and lack of testing is making it restricted in usage at the moment however it is believed to have a major impact in areas even apart from financial where it is used today. A public blockchain makes information exchange easier and with the peer-to-peer network it is collaboration between the users that reduces the necessity for a server or middleman (Cearley et al. 2016).

To conclude it is a shared ledger that is decentralized and trusted allowing a new way of communication where trust was not before existing (Cearley et al. 2016).

Selection of blockchain as a technology of research:
Blockchain is interesting investors in a way not seen at any other emerging technology and is getting more and more attention (Milani et al. 2016). This in itself makes the technology interesting for researching. Furthermore the author states that the connection to communication, sharing and trust is clearly a part of the foundation of blockchain. Furthermore the collaboration, communication, sharing and trust as values is linked to openness and sharing economy, which is a core for blockchain. Noticeable is also that this report aims to investigate new technology and therefore using Gartner's report "Top 10 Strategic Technology Trends for 2017" is valid source of information.

The selection and argumentation for blockchain as a technology, to achieve digitalization in order to obtain more collaboration, communication, sharing and trust will lay foundation for the report.

3.2 Blockchain technology

An explorative and descriptive chapter about blockchain technology.

3.2.1 Introduction to blockchain technology

"I've never seen a technology that I thought had greater potential for humanity." - Don Tapscott

Blockchain is not easy to apprehend and is a different thing for different users, however the base function is most often described as it being a distributed ledger that can store and manage all information entered in to it. The initial one kept track of all Bitcoin's transactions, a digital currency. The blockchain ledger made it possible to transfer money without a bank (O'Dwyer, 2015). Underwood (2016) also gives a good description of blockchain and states that blockchain brings the digital capabilities to a new level where the underlying levels are firstly mainframe, secondly the Internet and where the third becomes blockchain. The new level means possibilities never seen before in terms of immediate and everywhere computing.

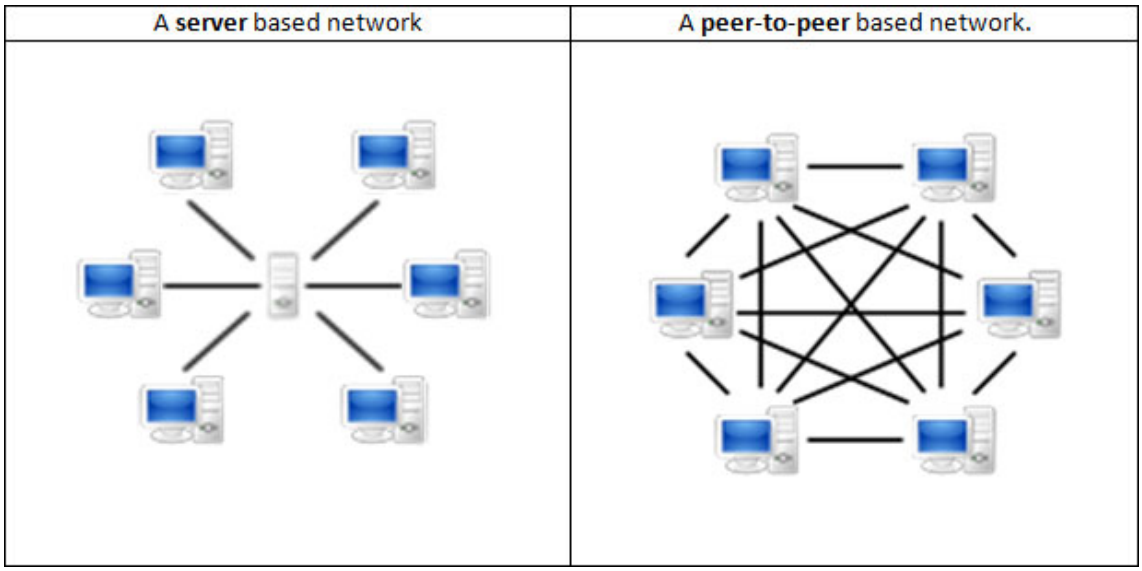

Figure 1: A visualization of the different types of network (Gigatribe, 2017)

The cornerstone to blockchain technology is that it is a decentralized network with a peer-to-peer constellation (See Figure 1). The peer-to-peer network combined with mainly cryptographic and distributed data storage enables a technology that does not require, in theory, any centralized functions or authorities such as governments or

banks. To simplify, banks today work as an ensuring body that register, verify and complete transactions. When transferring online people want and need that central function to make sure it is legit, compared to cash transfer hand-to-hand, which is easier to verify oneself. Emergence of blockchain technology allows such trust demanding transfers of information, or money in this example, that was basically not possible before. The blockchain is structured in such a way that the information put in to the system becomes visible for the network, enabling it to be compared and validated by the network. Hence the information is not possible to be tampered with, creating decoupling from the reliance of central functions. Simplified it is then possible for individual interaction in the space (Wright & Filippi, 2015).

A chain of blocks builds up blockchain as the name suggests. Each block is linked to other blocks, which is what creates the chain. Each block consists of a certain amount of information and a key for validating that data, a key to an algorithm. These algorithms ensure that nothing is tampered. Each node in the network, for example a computer, has a copy of the blockchain. When new information appears the nodes communicate to ensure and legitimize the information in regard to the rules and then, when consensus is reached, adding a new block to the end of the chain. Basically making a block an encrypted bit of information. Legitimization has to be done when using in a peer-to-peer network since anyone can add information to the chain. An added block is undeletable, which means a permanent record of historical activities that cannot be changed without the right authorization. This transforms individuals, with none or little trust to each other, in to a trusted network (Wright & Filippi, 2015; Abeyratne & Monfared, 2016; Swan, 2015; Christidis & Devetikiotis, 2016).

The blockchain benefits can be summarized as (Champagne, 2014):

- Decentralization: Does not require any central entities such as banks due to the network of nodes, peer-to-peer, that blockchain is made up from.
- Transparency: This depends in what sense it will be used but initially the network was open to everyone to see. A company use may be transparent in another sense than the original intent.
- Autonomous: The network does not rely on steering from a central point such as a bank to be utilized.
- Secure: Mathematical algorithms will ensure consensus and the blockchain records all interactions. The consensus makes it theoretically impossible to tamper with.

3.2.2 The Functions of blockchain technology

In order to investigate the possibilities with blockchain, it is important to understand what functions blockchain have. These three functions that will be presented are the functions that has been found most relevant when researching blockchain.

- ***Smart contracts – Important because:*** *Digitalized contracts that first with blockchain can reach its potential and is a stepping stone towards higher level of governance and overhead automation.*
- ***Ledger – Important because:*** *The foundation of blockchain. Blockchain is the new way of ledgering and is a database of shared information in the form of a ledger.*
- ***Digital signature – Important because:*** *A decentralized ledger, blockchain, needs a way to keep track of who is interacting with it in order to maintain security and reliable content.*

3.2.2.1 Smart contracts

Smart contracts are the digital revolutions equivalent to a standard contract. The concept is not new, introduced by Nick Szabo in 1994, but is becoming a vital function in the blockchain revolution. These contracts are basically a digital translation of the contracts accepted by the modern society's laws. The smart contracts allow a more cost effective and more secure digital creation of relations (Szabo, 1997). Ammous (2016) explains it as today's contracts are "drafted by lawyers, judged by courts and enforced by the police", so the connections to cost effectiveness are easily drawn when letting smart contracts be written through code and encoding them in to executing them selves. Smart contracts are what embody the predicted potential of blockchain (Hancock & Vaizey, 2016).

Hereby an example similar to the founder's, (Szabo, 1997), own example, as a description of how the digital translation would function, will be used. Imagine a contract between a landlord and a tenant. With a classic contract the tenant will get the keys when the landlord has the money because there are often trust issues. With a smart contract, there will be the same contract but in a digital form, which can distribute the key (requires a digital key) according to the contract. For example the landlord will sign the contract knowing that the contract will distribute the key when the contract detects the money transfer. At the same time the tenant will not have to pay in advance. If the tenant does not fulfill his end of the contract, for example missing payments, the contract will simply give the right to the key back to the landlord. Peters & Panayi (2015) means that this type of contract will potentially revolutionize the society in terms of contracts and its surroundings, heavily due to the elimination of human intervention when utilizing and forming the contracts. The contracts can by this logic be seen as a "trusted third party" (Delmolino et al. 2016). For these types of examples, where a

smart contract is used for physical assets, the sub category smart property can be used (Hillbom & Tillström, 2016).

The utilization of smart contracts as a blockchain application is indeed favorable. Smart contracts are seen as vital for blockchain being spread widely (Kim & Laskowski, 2016). However there are issues that have to be directed before smart contracts can reach full potential. Peters & Panayi (2015a) mainly describe the issues through three areas. Firstly there is the problem of scale, when blockchain increase in users it will be scale issues when smart contracts have to track and measure increased number of variables encoded in the contract. Secondly, blockchain is suppose to ensure a trustable network for intervention between non-trusting individuals, this means that trustable coding has to be performed in order to continue being a trusted network and ensuring the trustworthy of smart contracts. Thirdly there is the issue of contract law in the real world, specifically how to assure the legal aspects of the smart contracts.

Today's companies are using contracts in several connections to the companies. Suppliers, customers, employees, contractors, banks and insurance companies are just some examples. Utilizing smart contracts, as in the rental example, could greatly reduce the necessity of staff handling these functions, due to de automation. Using automated executed contracts when dealing with employee contracts could seem inhumane but there are human-run usage of these as well, with a voting function as a variable for execution of smart contracts. The smart contracts then become reliable and cheap governance for the companies (Omohundro, 2014).

Omohundro (2014) further states that it is predicted that smart contracts will interact with everything in our lives, but in order to interact with the physical world without humans there seems to be a need for Artificial Intelligence (AI) or Internet of Things (IoT). This is further supported by Ghaffari (2016) and described through that blockchain is predicted to be the ledger technology for communication between devices. In the rental example there could be a clause that says "No disturbance of the neighbors by playing music louder than 100dB after 10p.m., otherwise a fee will be issued". In order for this clause to fall out there need to be some dB measurer with a clock that can be connected with the blockchain and give input variables to the contract.

3.2.2.2 Ledger

Ledgers have existed for a long time and are a core of the functions in society. Today the majority is in a digital form and mostly known for recording assets such as money. Blockchain however enables a new form of ledger, which can be defined as a global decentralized digital ledger (Brody & Pureswaran, 2015), which is very similar to the explanation used by Pilkington (2015). This is much how Bitcoin got its spread, due to the independence from centralized society functions such as banks. The transactions and the ledgers were decentralized. A decentralized, shared or distributed ledger is now a reality through blockchain where everyone in the network has their own identical copy of the ledger that will be updated if changes are made somewhere in the network. The ledger is not restricted to money and can contain any information (Hancock & Vaizey, 2016).

The Bitcoin ledger was truly a ledger where anyone could intervene, it was public (Ghaffari, 2016). However as Hancock & Vaizey (2016) explains, this does not have to be the case since the openness can be restricted to a certain amount of people, similar to a police register. Pilkington (2015) names this hybrid to "partial decentralization". Hancock & Vaizey (2016) elaborates regarding a hybrid and states that the decentralization can be controlled to suit the company's use of blockchain as a ledger. It can be controlled and open to certain members of the blockchain, which makes it suitable for companies and not only for open source purposes. In addition it has the possibility of creating higher transparency, creating a more trustable relation with suppliers, customers, employees etcetera and increase the data sharing ability in order to increase efficiency. The use of a shared ledger as a source of information certifies that at any point in time the information on the ledger is the most recent one and no hesitation regarding if it is the latest version has to be accounted for.

The different types can be described as permissioned, unpermissioned, distributed and shared ledgers (Hancock & Vaizey, 2016):

- Unpermissioned ledger – is signified by the lack of ownership. Anyone can contribute to this type of ledger without restrictions, like Bitcoin.
- Permissioned ledger – is signified by ownership. In order to add something consensus has to be reached among the predetermined actors, for example every department manager within a company. Creates digital signatures.
- Distributed ledger – is signified by usually being public. Consensus has to be reached among chosen validators in order to add information.
- Shared ledger – signified by a company or a closed group and giving different permissions to different people. Can contain more than one possible ledger designs.

Hancock & Vaizey (2016) states that the terms are under development and are often interchangeable. Especially shared ledger, distributed ledger and blockchain. Blockchain is a ledger due to the chain of blocks that are linked and then can be read as a typical ledger. The blockchain can create rules regarding a single piece of information in the ledger and not solely for the whole database as conventional, which makes it unique.

3.2.2.3 Digital signature

Digital signature becomes of high importance because of decentralization and a theoretically trusting network. A digital signature is a way of identifying oneself on the blockchain. This is nothing new in society but when trusting a decentralized network it becomes of higher importance. It has to be ensured that the information on a shared ledger is only visible to the intended ones. From a company view, with a partially shared ledger, it authenticates employees and employees with the right access. This eases the sharing of sensitive information on a big scale with a high amount of trust, which however is a similar mindset as today in a non-blockchain environment. Today's cybercrimes and theft of intellectual property are a threat to a company's profit and continuation. For example supply chains are an area under certain threat, hence the extents of regulations are increasing. Digital signatures within a blockchain then become of great importance and with a functional system blockchain can help in the fight against intellectual property theft (Hancock & Vaizey, 2016).

Zyskind et al. (2015) proposes a system with digital signatures and to show an example, in order to easier comprehend blockchain usage of digital signature, a use case will be described. An application or access point to the blockchain is created for reading the products in action (PIA) in the supply chain at a manufacturing company. Blockchain is then programmed to handle two states for the access point, access management and data usage. A new employee needs to access the information and will then send a request for access, a digital signature is then created linking to the identity of the new employee. In the data usage state the new employee then might have view access or change access depending on company role. This is programmed and can only be changed by the identities with the right access rights, typically Human Resources or top management. The employee one day changes the information in the PIA data and blockchain then verifies the digital signature through consensus among the nodes and the data is then changed, posited the employee has the right to alter that specific data point. By the verification of the digital signature the network ensures that it is an employee of the company as well as an employee with the right access rights. This information alteration is then stored, which enables a trace of who did the alteration. Hancock & Vaizey (2016) provides an aligned comparison with the Internet and stresses that it seems like what Internet already provides today, through for example Public Key Infrastructure (PKI), however the blockchain enables a more proficient and powerful solution than the ones today, that for example exists in today's bank applications.

3.2.3 Need and functionalities of blockchain technology specific to manufacturing

Supply Chain Management has increased in importance since companies realized the benefits of openness towards other actors in the supply chain. Lummus & Vokurka (1999) mean that being less isolated from the rest of the supply chain can increase competitiveness.

Supply chains that are complex, stretch globally and between companies have proven to be hard to keep track over. Tracing or tracking products can be done in less complex supply chains or in parts of the supply chains. For example package delivery companies have shown some real time tracking, however this is only a part of the products journey in the supply chain. Today companies use specialized companies in order to integrate, map and understand the supply chain (Pflaum et al. 2017). Blockchain however could be a solution feasible even in complex supply chains (Kim & Laskowski, 2016). Underwood (2016) provides another interesting input regarding the complexity. The complex supply chains can easily involve countries under development or underdeveloped countries. The common denominator however is then the even bigger focus on the trust part of blockchain. It is harder for developed countries to see the value of increased trust, this does however increase the potential of blockchain within complex, global supply chains.

Kim & Laskowski (2016) did a study providing useful information regarding the industrial need of blockchain. When company managers were asked to assess what importance blockchain could have in a more integrated supply chain it was shown that ledgers and smart contracts are the two that, today, are perceived to have the highest impact. The security offered through digital signatures was shown to be a key functionality in blockchain as well as the transaction function from a business perspective. The conclusion of the research is though that one of the greatest impacts of blockchain is the possibility of creating a cloud service that everyone in the supply chain can share in an easier way, a blockchain ledger that is shared consisting of supply chain data. Korpelaet al. (2017) add that the blockchain is a promising solution for the ease of a digitally integrated supply chain that the complex supply chains have been trying to achieve for years.

By usage of blockchain in the supply chain it creates a more secure, transparent way of tracking the transactions along the supply chain. By the creation of a history of a product, severe reductions in costs, time delays and human errors can be achieved. That through key functionalities where blockchain technology could offer significant impact are (Vorabutra, 2016):

- Recording – quantities as they move from along the chain.
- Tracking – all type of significant documents.
- Assigning – or verifying properties or origin of product.
- Linking – a digital ID to a physical asset.
- Sharing – vital information about processes regarding a product between all actors.

The above functionalities are proposed from a SCM perspective, if viewed from a PLM perspective the data or functionalities that, suggestible, will be stored and used with a blockchain are (Abeyratne & Monfared, 2016):

- Ownership record – A previous owner list updated through the transfer of the asset.
- Time stamping – All entries of information are given a time stamp to show, chronologically, the life of the asset.
- Location data – Works in the same way as time stamping but shows a geographical, or similar, location of all entries.
- Specific data – Specific data regarding the asset that are relevant for the actors in the supply chain.
- Environmental data – Information about the environmental impact.

Interesting to note here are the similarities in what functionalities that are given by a blockchain presented from two different perspectives within manufacturing.

To further understand the need for blockchain within manufacturing by supporting the PLM-systems: There are incentives for a company to decrease product costs and increase product revenue. PLM is one way of achieving that. PLM improves key factors for a company such as time reduction, quality-, financial- and business performance Hence why PLM is of such importance for companies today. It is a system for managing the products over their lifecycle, from idea to disposal. It manages therefore everything from idea, to part, to product, to portfolio of products (Stark, 2015).

Morabito (2017) describes the link between blockchain and PLM through that blockchain has the possibility of vitally functioning in enterprise systems (ES) such as PLM. There are already systems in place for PLM and an initial step in order to adopt the disruptiveness of blockchain is to integrate it in to existing software. That will ease

the general awareness, understanding and adoption of the technology. This can be of vital importance in the future when blockchains might impact all corporate interactions. As stated, one of the main benefits of blockchain is the trusting network. However this is not the key issue for a company that wants to support their internal ES.

To show more concrete potential an example by Rizzo (2016) is used. The technology has come to prove it self so promising that the worlds largest mining company is now implementing it due to the benefits described above. Today spreadsheets are used to keeping track of where assets are, with blockchain a ledger can be used to better ensure real time data. The vast use of outside actors, in the mining process, across the globe results in a need for blockchain technology. With an interface designed for the outside actors the initiative is hoped to be promising and is a stepping-stone for the production use cases of blockchain.

3.3 Disruptive potential and pitfalls of new technology

One main benefit of usage of blockchain technology is the possibility of innovation derived from a decentralizing new technology (Vorabutra, 2016). No one could predict how important Internet would be for society or what it could possibly be used for long after implementation (Wood, 2015). Initially Internet was an overlay of the former phone network, Internet then progressed in importance and usage and lead to a total re-design of the phone network (Peterson et al. 2003). Blockchain technology has been referred to as the new Internet, hence the impact it can have to current society infrastructures is intriguing. New technology can be tricky to understand but may still be a way of capitalizing or reach efficiency. The amazon founder watched as the web grew by 2300% in a year, he did not have to understand all the details about it to understand that he wanted to use it as a platform for his business, this is the way Airbus is thinking about blockchain technology and they are not alone (Holl, 2017).

However it is also interesting and important to further acknowledge the immaturity of the technology and therefore further elaborate about the general potential while risk assessing.

3.3.1 Disruptiveness of blockchain

To define disruptive technology, it is technology that initially does not satisfy the mainstream need and is inferior to main technology. It satisfies niche markets as a start. After R&D spending, as time pass, the disruptive technology will outperform the prior technology and become the superior choice, not only for niche markets. To further elaborate about a disruptive technology, to show tendencies for future superiority, some main characteristics are common for disruptive technology. These are that the technology is cheaper, simpler, more reliable and more convenient than existing technology (Danneels, 2004).

Parallels can be drawn from the definition of disruptive technology to blockchain. Blockchain initially satisfied the niche market of digital currency, initially Bitcoin. It does not yet outperform existing technology but R&D is extensive at this point. Even if no one can predict the future, the technology has moved from niche market in to heavy R&D spending. Whether blockchain is disruptive or not is hard to tell and can be a matter of perception for the company or industry that will associate with it. A technology may be disruptive to some and at the same time something to truly capitalize on for others (Danneels, 2004). For example blockchain is possibly not disruptive to an aircraft manufacturer such as Airbus, blockchain do not substitute airplanes but do possibly disrupt some of the existing processes. There are several examples of huge companies that did not adapt to the digital transformation and severely failed, such as Kodak, Nokia and Xerox (Quora, 2012). To understand the phenomenon of disruptiveness, the competitiveness becomes key. Charitou & Markides (2002) further elaborate about the issue aligned with the adoption to digital transformation. Disruptive strategic innovation has been seen before and means that a new innovative strategy grows at the market, disrupting the mainstream businesses. One often-used example is the full service versus low budget airlines. It is not something that the big companies missed, it is a question of how and if to respond to new strategies that takes shares of the market. The problem is that it can contradict to their current strategies and damage relations with other actors in the supply chain. Disruptive strategic innovations have similar characteristics as disruptive technology and the similarities to blockchain are visible. However it raises new questions in terms of the previous strategy, how much that can be bent in order to coop with the new inevitable innovation trend. Once again it is to be mentioned that blockchain is not a disruptive strategy innovation for all companies. However similarities can be drawn to the historical disruptive strategic innovation examples and how to respond accordingly. There are different ways to respond in order to increase or not loose competitiveness and blockchain could become a cornerstone to competitiveness in industries.

To do a comparison to the Internet and its journey from a potential technology to a societal game changer, Internet, or more precisely the opportunities that Internet and the web gave, is now a vital part of every day life. However it has been a development in

importance. Internet was a disruptive technology to many industries. The technology or the platform meant a superior advantage in business offering. Companies could provide digital interaction with customers, resulting in cost cutting and often better service. It also meant that companies could collect data in a completely new way, leading to better control of customer demand. It also meant that other sets of data could be collected, leading to more efficient supply chains and cost cuttings. It lead to new ways of interacting with customers, this seem irrelevant to large manufacturing companies selling few products business to business. However in terms of communication it becomes relevant in other parts of the supply chain. It did also lead to an accessibility that decreased the amount of market asymmetries, which can be interpreted as transparency (Afuah & Tucci, 2001). In conclusion, Internet became a superior technology not only for the classical online versus physical bookstores but also opened doors for almost every company.

3.3.2 Pitfalls with blockchain

Potential of blockchain becomes clearer through out this and other research but it is also of key to not let the potential blind one and realize that it is sometimes possible to achieve the same results with today's Internet and software. It is of importance to understand that the technology will open new possibilities rather than fixing all the current ones. The technology is a platform like Internet where ideas and applications can take advantage of it in order to create new possibilities for business (O'Dwyer, 2015). It is also of importance, as Underwood (2016) explains, when evaluating the blockchain's possibilities to understand that existing corporations will experience more barriers than the startups that are using blockchain. The agreeing process within a supply chain regarding a common blockchain system is more troublesome than a startup that attracts collaboration based on their set of rules. However, even though problems are described regarding blockchain implementation it is important to recognize the potential gains. The use case of transparency giving more sustainable information to the customer gives a hint of what could happen if one cannot provide the information while competitors can. However it can also become a problem, posited a growth of blockchain, that with leveled asymmetries along the supply chain suppliers benefit from the blockchain and will only choose manufacturers that fully function on a blockchain platform (Badzar, 2016).

What is to be remembered about blockchain technology is its immaturity and the fact that most research presented are not a reflection of todays capability but the future capabilities (Furlonger & Valdes, 2017).

4. Blockchain in the supply chain

Following chapter will build on the potential in a more concrete way.

One of the blockchain's key attractions is the decentralization and one might argue the level of decentralization when used only inside one company. These usage areas are therefore focusing on inter-company usage where one can actually benefit from decentralization.

By the usage of blockchain in the supply chain it creates a more secure, transparent way of tracking the transactions along the supply chain (Vorabutra, 2016). This presented statement will be further elaborated in this chapter in an explanatory way in order to show the reasoning behind blockchains usage areas. The statement is not literally describing the usage areas but gives key words that in a good way describe the usage of blockchain, summarized the statement is an inspiration source for potential of blockchain.

4.1 Specific usage areas for blockchain in the supply chain

The ten functionalities together with the three functions lay further ground for the three presented usage areas beneath, transactions, tracking and transparency. Functionalities are what the blockchain will contribute with. To exemplify, the video recorder has the functionality of recording movies. While the features are what tools that blockchain has to work with. To exemplify, the video recorder has a log in function. These to are connected in the sense that in order to use the functionalities one or more of the functions must be used. To exemplify, to be able to record a movie one has to log in to the video recorder. Reminder:

Functionalities		**Functions**
Recording	Ownership record	Smart Contract
Tracking	Time stamping	Ledger
Assigning	Location data	Digital Signature
Linking	Specific data	
Sharing	Environmental data	

Transactions: Blockchain will contribute to this usage area by providing the ability to Record, Track and Share as well as providing Ownership record, Time stamping and Location data. In order to do this it has to use all of the blockchain functions.

Tracking: Blockchain will contribute to this usage area by providing the ability to Track, Assign and Link as well as providing Ownership record, Time stamping and Location data. In order to do this it has to use all of the blockchain functions.

Transparency: Blockchain will contribute to this usage area by providing the ability to Share as well as providing Time stamping, Location data, Specific data and Environmental data. In order to do this it has to use the blockchain functions ledger and digital signature.

4.1.1 Transactions

"Banking is essential, banks are not" – Bill Gates

Korpela et al. (2017) explain today's situation where supply chains have to rely on banks when dealing with intercompany transactions, a third party such as a bank are most often involved when products change hands. The lack of trust often even means involvement of two banks, one representing each company, seller and buyer. This process has existed for a long time and works as a guarantee between companies, however there are financial services dealt with that are still not digitalized. A manual oriented process most often equals time losses and an obstacle for a digitalization. Furthermore they are not designed for supply chain documents resulting in system clashes between the seller and the buyer when trying to deal with each other's information. Banks use the seller's information when delivering these financial services leading to a troublesome process when the buyer wants to handle the documents in their system. Further there are issues regarding security with the use of a third party. Banks are known to be secure and they have secure ways of communicating with each other, this however becomes costly.

The implementation of blockchain could result in a full solution. Underwood (2016) means that it functions as prevention to fraudulent behavior in transactions. By using the features of blockchain; smart contracts, ledgers and digital signatures it appears a possibility for decentralization without loosing functions when doing business with companies along the supply chain (Korpela et al. 2017). That is because blockchain preserve the truth between actors that have little or not trust among them (Staff, 2015). The information will be available but without knowing what to use it for without the right signature or permission. If some intruder would try to manipulate the transaction or information the other nodes that holds the same information would not accept it due to the rules set out initially. By using digital signatures or PKI, which encrypts and decrypts messages for example, the notification of a transaction can be made between the companies and a bank become obsolete (Korpela et al. 2017). Smart contracts or smart property can be used to ensure the right ownership of products until payments are done (Peters et al. 2015b). The smart contracts further enables the financial services to

be digital as well as filled with new features set out by the two parties. For example today the buyer's bank ensures the seller's bank that the buyer is going to pay, and the other way around that the actual goods is going to be delivered. A smart contract can ensure all this (Korpela et al. 2017).

To conclude, the functioning but lacking process that banks offer today show several missing functions such as time stamping and complete information from end-to-end. Time stamping is also a vital functionality for the other found usage areas and especially tracking. Furthermore a system with four companies involved naturally results in a slow and cost ineffective process. On top of that it allows human mistakes to be made when information change hands, often manually, through companies. A blockchain offers a more cost effective transaction process while, and because of, a simplification of the process. The use of blockchain and therefore elimination of the banks trust function results in very low costs (Korpela et al. 2017). More specific, the banks are no longer needed as a verification entity for the transactions because it is done by blockchain's cryptography (Peters et al. 2015b). Use of a smart contract ensures that an asset has the right ownership during a transaction process (Szabo, 1997).

4.1.2 Tracking

Possibility of tracking a product and its parts with higher efficiency throughout a supply chain would be of high value to manufacturing companies today. This is due to the complexity of the supply chains today and due to the hardship of the tracking with today's technology (Abeyratne & Monfared, 2016).

Complex supply chains can stretch all over the world and contain numerous actors (Abeyratne & Monfared, 2016). Hence it is complex to keep track of information regarding products for companies today. A company might need immutable information from origin until end use. Here is where blockchain can show one of its use cases. Blockchain's ability to allow immutable information records, through a ledger of vital supply chain information, opens new possibilities of tracking. By assigning an ID, for example with Radio Frequency Identification (RFID), the assets within the supply chain becomes more traceable. Today's complexity and existing technology are not sufficient enough for the level of tracking strived for. However RFID have to be implemented early on for the tracking to work fully with blockchain technology (Tian, 2016). Theoretically by the assignment of an ID to each part or product allows tracking and traceability all the way from raw material harvest to scrapping or recycling. The cornerstone is that the physical asset gets a digital profile that keeps being updated throughout the lifecycle or supply chain (Abeyratne & Monfared, 2016).

Blockchain allows a trustable transfer of information where each actor in the supply chain store information about the part or product. Through smart contracts, when moving to the next actor in the supply chain, the right to add information will be signed

over along with the products. Smart contracts are used to create ownership to the actor of the asset during its lifecycle. Smart contracts will ensure that only the right digital signatures have access to enter information about the asset as well as the authority to transfer it to the next actor, here smart contracts ensure that the digital signatures are correct and stores the transfer as well as changes which digital signatures have access at the moment (Abeyratne & Monfared, 2016).

With blockchain it becomes a reality to store all information about every piece or product at every actor in the supply chain. This through a digital ID, which means that every part is registered on the ledger (Peters et al. 2015b). The data about assets can be updated and entered automatically or manually depending on the situation. That instead of separate systems that store information, which may or may not be visible to the rest of the supply chain. It also ensures that it is up to date and not tampered with, the trust of blockchain (Abeyratne & Monfared, 2016). This creates a chain of information that moves in the same pace as the product were all information agreed on will be stored, similar to parts of the usage of PLM-systems today (Stark, 2015). Correct information could lead to more efficient supply chains, higher product quality when flaws become visible as well as increase trust among actors (Mattila, 2016).

To conclude, with RFID blockchain technology and supplemental technology it becomes possible to record, track, monitor, link and share information and assets. The true benefits then arise when this is set to use. To angle an example to manufacturing: a batch of products is tested at the manufacturer and the batch is not meeting requirements. Lets say the metal in a batch of screws contains too much slam products. Hence the advantage of blockchain features they can be traced immediately to get to the source of the problem as well as realizing that other parts created at the same time are in risk of having the same quality lack. This saves a lot of time in quality inspection and risk management (Tian, 2016). The tracking will also provide vital information regarding the logistics of products or parts being in movement, which enables a more environmental resource efficient supply chain. It also makes all the transports visible for the actors meaning effort can be placed in better logistic decisions (Badzar, 2016).

4.1.3 Transparency

Imagine that a company have suppliers which all have suppliers and so on, then it becomes hard to ensure that quality, ethics, origin, handling etcetera is as stated. The number of third tier suppliers, for example, can become extensive in number and hard to oversee for companies. The complexity of supply chains has gradually increased in difficulty to keep transparent (Donovan, 2016). In regard to this Abeyratne & Monfared (2016) states that supply chain visibility is of high importance and a key challenge for businesses. The transparency is linked to tracking but can also open other doors. If end-to-end visibility of a supply chain are being able to model the flow through it will open up new possibilities of risk management, opportunities for operations and increased sustainability due to better information about low-level tier actors. More information about a part or product from these actors enables better understanding of a part and its possibilities, which is desired by most companies. However there are today no good centralized systems that are functional enough, there could be mapping and collecting of information but then the problem with stored information of key factors of an entire supply chain still exists, it is too sensible. The usages of these systems are not common even though the benefits are truly desirable. The blockchain however can be a solution to this problem. The security of the blockchain enables these systems to become functional, hence transparency within the supply chain can become a reality.

Abeyratne & Monfared (2016) further explain that by the use of an open record, ledger, the supply chain and its actors can get an overall picture of the chain where the information of current processes, transactions and key information is shared within the supple chain. Today, without blockchain, usually only partial information is accessible and usually only for the biggest actor in the chain which makes tracking and other key information based on trust. Even if trust exists it can be hard to ensure that parties have all the information they want or that they did not know they needed. By ensuring that blockchain's immutability and digital signatures secure transparency information can be transparent and new usages of parts or understanding why parts do not function as they should could be understood.

To conclude, the ability to visualize the supply chain enables a leveling of information asymmetries, hence allowing the actor with the actual best capabilities for the position in the chain to take place. This allows balances between actors resulting in fairer transactions where trust is no longer as needed to spend time investigating, potentially speeding up the process. Moreover it could make certain that standards, certifications and other regulations are actually followed resulting in a better choice of actor, more honest actors and in the end a better end product. In conclusion the transparency bring more information to the surface that in the end could be used as a verification of the quality of the product. The quality and sustainability of the product are vitalities in modern society, hence potentially gives the end product a competitive advantage. Viewed from an environmental resource efficiency perspective the transparency will

also provide vital information for the company in order to make choices in an environmental direction, for example through environmental certifications being followed (Badzar, 2016). Previous and current solutions that use specialized companies for transparency and understanding the supply chain could now be replaced by blockchain and potentially eliminating the middle step that meant significant costs. It also eliminates the slow process, hence the elimination of the middle step results in a more cost effective digital supply chain (Pflaum et al. 2017).

5. Interview results

In this chapter an extended view of the research area is presented through interviews. The interviews give a deeper and more specific understanding, in order to reach conclusions in this report. Furthermore the interviews will in some parts be presented in a way so that it will look like normal references, this is due to it being a prolonging of the already done research and also since it is presented in a way where different interviewees are presented alternately.

To make the connection to literature more clear the chapters will be connected to the table in chapter 4.1.

5.1 Security

In order to understand the security aspect, if blockchain is used and implemented for these usage areas, interviews were conducted with individuals that have work experience regarding the topic. This leads to a better understanding of what is required for using the blockchain in the predicted areas.

In the security aspect it becomes a question of which functionalities that are too sensitive to store and use, from a security perspective. It is mostly about ledgering regarding the functions.

This report as described before is focusing on inter-company blockchains. However when blockchain is stretched over the supply chain there is need for higher security than in a private blockchain. If each node is known and under control there is no need to apply a higher level of security. Known and under control responds to a private, shared and permissioned blockchain. The idea is to secure all the exchanges on the blockchain in order for an ideal implementation, on public chains there are complex algorithms to ensure that anyone can validate a transaction according to the rules and it enables random nodes to validate the information. Blockchain can bring a good level of security but the problem with that is then performance. Today the right amount of security equals to slow performance for a blockchain to be ideal for its predicted tasks (Interviewee 1, 2017). This is a problem when trying to relate literature to actual implementation, however there are different levels of information that can be put in the blockchain. It is not yet decided on how much data that will be exchanged but a minimum is milestones of the total workflow, in order to be able to know what have happened along the supply chain (Interviewee 1, 2017). This might lessen the amount of sensitivity while still giving a lot of useful information.

It is important to improve the global security level attached to blockchain. Due to the fact that, for instance, if ledgering some of the activities regarding design stages or the production stages of the aircraft there is also need for ledgering activities that is done outside of the company. That means that it is vital share a blockchain across the supply chain thus have to make sure that this sharing is not harmful to any actor in the supply chain. The key is a robust infrastructure. It is all to make it more secure and hard for hackers to understand what happens and harder to attack (Interviewee 2, 2017).

It is clear that the security is a main issue and it is what is keeping the implementations from reaching the global potential described in literature. It is discussed with both permissioned and permissionless blockchains where the security would increase with permissioned but would not be ideal since it is decreasing the openness. However as literature and Interviewee 1 describes the digital signature is already a major step towards more security. Another thing Interviewee 1 states is that, for security, data is not going to be stored on the blockchain but instead a hashed link to the data storage. By saving only milestones, which mean to store proof of what has been done in all levels of the supply chain, it becomes safer (Interviewee 2, 2017).

5.2 Present state

In this chapter it is mostly about expressing the current state and understand the present to see where blockchain could have impact. Therefore all functionalities and functions should be kept in mind when examining this chapter. However mostly discussed are areas regarding Ledger and Smart contracts as functions. No specific functionalities should be raised above the others due to the exploratory nature.

The presented information in this report is shown in a rather blockchain favoring way. However, as Interviewee 4 explains, initiatives to implement several tools to exchange information have already been done in terms of being able to control the supply chain, the purpose is however the same, to get additional information regarding the complex supply chain.

Today it is still a traditional way of working, that every week information is sent to the suppliers regarding the existing manufacturing program, with request of having certain parts delivered at this time and similar. In order to have a kind of forecast, the supplier has to acknowledge the information and responding. When a response is received people take that information and notifies potential discrepancies from the initial order. Today's communication with suppliers is good with level one suppliers. There is not good communications down the levels so it is not possible to predict if surprising things are happening that could have an impact. The reliance is only on the first level and it is a beneficial of having more real-time information and more governance (Interviewee 4, 2017).

Collaboration exists, which in argue against blockchain enlightens that information exchange exists. However at the same time shows the automation that blockchain could bring to an important area. This is also confirmed by the thoughts of Interviewee 4 who predicts that there is for sure need to continue to communicate to the supply chain network and with better technology capture the feedback more quickly and with more data. Today's traditional way of working with file exchanges through Internet that needs to be translated in to the local ERP is not optimal and takes a lot of time. More information more quickly, more agile and more secure is something that is desirable in this area. More concrete it is desirable to being able to build a network of information different than today, where conversation is made separately to each supplier, and instead information exchange amongst a network of suppliers. If this becomes reality Airbus will spend less money while having more information at the right time and then it enables to use the information for analytics internally. Analytics that is not possible today due to lack of information exchange or lack of correct and closer to real-time information. In continuation of analytics and anticipation Interviewee 3 says: The target vision of anybody in charge in a company is to have instant visibility about whatever happens wherever it is happening in the area, this in order to best understand what is being done and anticipate potential issues. Therefore whatever tool exists in order to better understand the present and the future is a benefit. This information given by Interviewee 4 and Interviewee 3, which is expressed as an ideal stage but not currently a vision, will be conceived of the blockchain consecrated as the blockchain has a clear potential while at the same time is not penetrating the field enough yet due to the immaturity of the technology.

Interviewee 5 presents the prospects and potential of blockchain by stating; blockchain is a completely new way of doing things, where the name of the game before was competition and now is collaboration. Today it is more about sharing decentralized realities. That is why a lot of current processes are inefficient because they were designed for the old way of thinking, where everybody was defending their competitive advantage. There are beliefs that if one does not collaborate, hence miss out on information, one is probably not going to survive. This is aligned with the drive behind digitalization where collaboration, communication, sharing and trust are keys. It can be called a paradigm shift. Blockchain is a symptom of this paradigm shift that already has started and each stakeholder has different interest in it. So to say that it is a single driver for researching blockchain is not that simple states interviewee 5, however one dominating factor is to increase profit margins that are eaten up by compliance. Compliance there to reduce risks for the banking system but is very costly. There is a need to digitalize and automate because there is no longer a luxury to have big profit margins.

Interviewee 5 further states that through digitalization the common goal can be satisfied and the compliance costs would go down as well as the need for overhead. For example if more than one bank is involved in the processes compliance are done at each bank. If blockchain and smart contracts can be implemented the banks can check the information. With blockchain the amount of compliance and regulatory work could go down through a digitalization, which would increase margins by lowering costs. If everything happens on the blockchain there would be less system and operational risk.

5.3 The industrial drive

Airbus has a knowledge base and shares it with a level one supplier. It is shared according to regulations and other policies but under that level there are sub contractors that work for level one. Hence Airbus cannot see all data that is exchanged between them and that can lead to problems regarding compliance and regulations and internal policies. This is the drive for blockchain research (Interviewee 1, 2017). This is an interesting fact that shows that the drive for blockchain technology research is the lack of transparency in the supply chain.

In 5.3.1-5.3.3 the same functionalities and functions as in chapter 4 become applicable.

5.3.1 Transactions

This usage area is, when analyzing the literature review chapter, a more specific one and is therefore harder to speculate about on a deeper level. The benefits brought up in the chapter are mainly that the banks are functioning as a trust entity and a translator between different ERPs. It also emphasizes the reduced manual labor in benefit of the digital communication system as blockchain is. The usage area seems promising in theory, however for the pace of the goods it is not a problem today (Interviewee 3, 2017). What would however be a benefit and a new function is the ability to not having to involve banks for reviewing actors of the supply chain's credit and can therefore start working faster (Interviewee 4, 2017). Furthermore as stated lacking in the literature chapter and the functionalities used in the usage area of transaction there is a need to get information about the product or goods in the same pace as the product or goods. It is beneficial to know more detailed about location of the goods (Interviewee 4, 2017). This expressed need correlates well with the theories expressed lacking in todays supply chain transactions.

When discussing the contracts between actors it becomes clear that it is an issue. The transactions chapter suggests that the manual handling of documents is time consuming and allows for human errors. Interviewee 4 states that automated contracts would be a big thing for everything within the company, not only along supply chain. This would be a revolution. The contracts are very long with the suppliers. This confirms the view

of time consummation at banks when handling the supply chain documents. Interviewee 4 confirms that they are very thick. Furthermore it would also be a game changer, when dealing with suppliers, that the transactions are automated with smart contracts when there are lacking of contract fulfillments. Interviewee 2 states that a lot of the company's overhead will be automated with an implementation of blockchain, this correlates well with the literature's statements about a more cost effective transaction processes due to simplification and digitalization.

Interviewee 5 contributes with a perspective different from manufacturing experts. The literature takes it as far as banks do not seem necessary in the future of blockchain and the manufacturing experts talk about the benefits of a more digitalized way of doing deals. However banks are fully aware of the potential of blockchain and there are substantial research done. The way of banking has changed a lot and one is that there now is an adaption towards a more digital mentality in order to survive. The bank of tomorrow is going to be mostly digital. Banking can then be viewed as not offering IT or digital services but more IT companies offering banking services. When investigating further what effect the potential of blockchain could have for the value chains, where banks are heavily involved, it is important to understand the situation today. In regard of that Interviewee 5 states that basically banks offers money. Furthermore generally all companies need access to credit, hence there is a balance when the companies get money and when they have to pay, and the bank fills that risk gap. That basically means that bank take risks and evaluates it. The better measurements of risk the cheaper for client. Banks absorb risks, not offer trust. This is an interesting point when observing that the literature claiming banks to function as a trust support between actors. Interviewee 5 further elaborates about the banks function in a blockchain ecosystem by explaining how a bank would fit in. With blockchain, a full digital identity of a company exists and therefore the shared reality is up to date and correct. This is prevented today due to the amount of manual exchange of information along the supply chain. When digitalized information can be trusted the banks can check the information needed to calculate risks in a more accurate way and at the same time simplify it. Regardless of all the potential of blockchain and all the simplification it is hard to imagine that banks will not be vital due to the function in society today.

5.3.2 Tracking

An interesting point that is given by the industrial view and are not taken in to account when reviewing literature is that the idea is that the subcontractors have the vision of their processes and Airbus has the vision of all processes. Airbus will own the blockchains, which makes them private but permissionless, and means that at Airbus level the activities are linked (Interviewee 1, 2017). This link opens up for understanding and the possibility to compare workflows and also see if each subcontractor is following the main pace. With this information Interviewee 3 explains what this could mean for a manufacturing company. The comparison between the workflows also means aiding towards going in to the full analytics exchange, where predictive actions can be generated, based on events that are happening or possibly will happen in the future, and be able to act and react. Today there is no problem when a certain part is needed at a certain time, the problems occur when something does not work. Then the whole chain can be in danger and even the delivery of the end product. If blockchain is the tool that enables an understanding of what is going on at the other end of the supply chain a more efficient way of working can be achieved. For example to have the information about that the aircraft that is planned to be assembled next month can not be assembled because a specific part has not started to be manufactured yet at a supplier because the raw material has not arrived. Ideally with this information the system is automatically proposing solutions where some of them might be automated.

The information gap that Interviewee 3 is mentioning is similar to the information needed and the purpose of tracking. The literature proposes that it becomes possible to record, track, monitor, link and share information and assets. The literature mostly mentions the tracking of a product but its functionalities also means that it is possible to see discrepancies from the main pace and therefore being able to predict future delays. Interviewee 3 mentions the automation of such a system and it responds well to what Interviewee 2 mentions that: It is so much information that no one has time to compare it now. However everything that can help the supply chain to more efficiently communicate in order to update about changes are well needed. Interviewee 4 confirms this and emphasizes that with new technology the hope is to be able to get more and correct information quicker and be able to bypass all this time inefficiency caused by lack of information. It would be valuable to follow each step in the supply chain even including supplier shop floor happenings and transportation.

5.3.3 Transparency

The interviews correspond well to the earlier presented chapter about the transparency usage area. The transparency is lost in complex supply chains. The chapter argued that higher transparency lead to more knowledge about parts but maybe mainly about that processes that are visible enables knowledge about the actions taken. Hence, that quality aspects are followed and regulations, certifications and other standards are followed. This correlates well to the industrial hypothesis, which Interviewee 1 explains as: The idea is to build a representation of the workflow and to put this workflow on the blockchain, which allows a comparison between the initial workflow and the monitored one. From that it is possible to see if there are any deviations and if they are good or bad. So the idea is to have a P2P network, a blockchain, to map the workflow by allowing all users to interact and add data. The P2P network will then provide a ledger with all activities of the process and the system will automatically compare the representation of the workflow with the initial workflow idea.

In order to achieve a higher level of transparency, but also the overall purpose with blockchain, the key is a higher exchange of data. It will not be big data but it will be sets of parameters and ensuring that these are the right ones. There is a need to get time stamps and signatures for these parameters in order to achieve higher correctness of data (Interviewee 2, 2017). One might see that data is possible to get today but it is easily delayed, lost or not even correct. Interviewee 2 emphasizes today's importance of correct data and more knowledge through exchange of data with the example: If higher exchange of relevant data is not achieved there will can issues similar to Volkswagen, deviation of what the products actually deliver with massive reproductions world wide as a result. The research and potential of blockchain is based on the hypothesis that the applications do not involve time sensitivity. When successfully getting rid of time delay, possibilities open up on a much greater scale (Interviewee 2, 2017). This is important to notice in the continuation of this research regarding the realistic argumentation of usage areas.

The transparency usage area discussed in literature gave the opportunity to reach an overall higher environmentally friendly supply chain by ensuring the environmental certifications are actually followed and similar. This is a vital part for companies and the issue is stated as: There might be things done in lower level of the supply chain that a company do not know or even not approve of. A blockchain is a clear way of understanding what happens along your supplier network. Not approving of can be exemplified as environmental cheating and furthermore wrongly information sharing and quality breaches (Interviewee 2, 2017). One reason might be that cheating occurs to focus on actions that create more value for the company. Up to 25% of an engineer's time is spent on just confirming that milestones or work are done, for example that global standards are followed (Interviewee 2, 2017).

5.3.4 Shared information system

It is interesting to note that all the interviewees quickly went out of present and started brainstorming about new potential areas that could be handled with an implemented blockchain. This has to be interpreted as; with a new system that is changing the way of working there are a lot of opportunities that will be opened up.

Examples:

- Same systems for all actors, which would lead to no old data in the system. Today old parameters lead to problems when calculating for new products or simulations (Interviewee 3, 2017).
- Maybe potential for maintenance if more information is correct and simulations is hence correct (Interviewee 3, 2017).
- Used for 3D printing missing parts when all information is digital and in access for the manufacturer (Interviewee 2, 2017)

These are a few examples mentioned from industry experts, no emphasizes are drawn from these specific ones. The interesting thing is the connection to what the literature review stated as: One main benefit of the use of blockchain technology is the possibility of innovation derived from a decentralized new technology (Vorabutra, 2016). The new ideas brought up during interviews indicate that the blockchain creates a whole new way of innovation and open up new opportunities.

6. Discussion

First in this discussion chapter the sub questions will be answered in order to be able to discuss the main research question.

6.1 Sub questions

In order to logically discuss and conclude the research, the sub questions will be answered separately.

What are the drivers behind digitalization that makes new technology desirable along a supply chain?

Digitalization is growing more and more and companies that want to keep a competitive advantage, or even survive, will have to adapt to it. However it is not the digitalization in it self that generates value. Digitalization is changing management processes and is also functioning as the new way of cost optimization. It therefore brings a new perspective to the meaning of digitalization. It is not only about digitalizing for easier use of information or digitalizing certain processes, if anything it is going towards a complete digital integration of the company's processes. A driver is to have more information and knowledge about the processes and physical assets, therefore the trend goes towards obtaining information outside of the company and stretch it towards the rest of the supply chain in order to collect more information. The ERPs do not fully facilitate this, they do not have the ability to collaborate with other ERPs in an automated way as well as ERPs do not function as a safe way to exchange information. It is not something new since they were simply designed for managing the enterprise information, however with the need for more information and trend towards stretching the information radius further outside the company there is a need for new ideas.

But how does one facilitate the new trend? It seems to be consensus that for a higher digitalization there is need for new innovative technology. The technology then has to be designed for not only digitalizing but to be designed to facilitate what drives value in digitalization. What can drive value is more knowledge and information and a way to do this is through a higher level of collaboration, communication, sharing and trust. So value generated from a digitalization can be evaluated in the success of a higher obtained level of collaboration, communication, sharing and trust.

What practical use cases for blockchain come for a manufacturing company within a supply chain?

The identified usage areas are Transaction, Tracking and Transparency. The overall observation is that all areas require involvement of other actors along the supply chain, which was the purpose of the research. However it further makes it harder to evaluate the time until an implementation. Looking from a technology perspective it seems to be possible in the future. What else are to consider in a time matter, which is not a main focus in this report, is the inter-company relations and managerial aspects. It was brought up that the relations might be one of the major risks when implementing technology across the supply chain. In this case there is also matters of risk for actual tension and resistance for implementing it, which could damage the potential of the usage areas as well as prolong the time to implementation. Furthermore these aspects makes the answer to the sub question partial since it then answers mostly from a technology perspective, which creates a gap between practical use cases and real implementation. One potential conclusion, drawn mostly from interviews with a large manufacturer but also from literature since it mostly do research from a large company perspective, is that if the largest player wants to implement blockchain for these usage areas it will probably happen easier due to the power factor in a supply chain. The beneficial large company will have fewer problems with convincing the rest of the supply chain to implement it.

Transaction: When reading the published research about blockchain and how it could function for this usage area it seems to have huge potential. It describes a lot regarding the flaws in the banking system and how lacks of a digitalized way of working are possible causes of errors. Blockchain can increase efficiency in the processes. It further becomes clear that use of blockchain in this area would be beneficial due to its fulfilling of information regarding the goods. The information gap where banks do their function could be tightened by blockchain functionalities. Use of blockchain within the transaction services will become necessary for an end-to-end supply chain digitalization.

That interaction with banks and transactions along the supply chain is going to change seems certain but it seems to go towards a simplification where banks are on the supply chain blockchain and instead the whole supply chain becomes more digital, not only within itself but by including other actors in it. The quote of Bill Gates about “Banking is essential, banks are not” seems to be true, however it should be combined with the mindset of banks changing to becoming IT companies offering banking services to make more sense. It then shows that the banking services will still be necessary but not in the way that they are done today. The bank’s functions today together with their strive for blockchain will meet the statements about eliminating the banks somewhere

midway and instead result in a solution with more efficient banking services for the supply chain.

Tracking: To discuss if a higher ability to track products through the supply chain is beneficial or not seems rather pointless. Every company wants more information so the question then becomes if there is a way to do it seamlessly enough. Blockchain has the potential to function in this area, the literature describes well how that would work. The functionalities and functions of blockchain are desired from an industrial point of view. The industry however rather explains it as wanting more information to be able to predict and react to discrepancies in product flow. Here tracking with blockchain is a way of obtaining this goal. What is concerning but not critical to the over all benefits is that it involves all actors, it might have a negative effect on the end result if there are gaps in the end-to-end tracking. Furthermore it confirms the innovativeness of blockchain when tracking is not the main thought for a solution. This area is potentially less concerned by the security due to the fact that the functionalities used are not necessarily meaning sensitive information.

From having a sufficient ability to track it mostly creates a base for development and efficiency rise. The information about the raw material in itself is merely of any use to a large manufacturer but when flaws, delays or the information about next shipment becomes visible production and supply chain can be improved.

Transparency: It is important to separate transparency from tracking in researching, in industrial use it is more likely to intervene. The use of blockchain for transparency aims to have more information through visibility. It becomes a way of gathering information regarding processes, which becomes a way of achieving higher collaboration. Hence, it could lead to more efficiency and higher quality of products. This usage area seems to be a drive for industry, it seems to be a main purpose in order to develop the business. The literature however is not paying as much attention in specifics to the area, most likely because the results are harder to pinpoint and evaluate. However it is very promising in terms of making sure that certifications, environmental goals, ethical work situations and other important issues in modern society are followed.

The transparency area can also be seen as a way of establishing a base of information to open up for business opportunities. It should be viewed as a way of information gathering through digitalization.

Elaboration regarding the three areas: This cannot be stressed enough, these areas should be viewed as tendencies of proof of that blockchain has concrete potential. However they try to show future capabilities rather than the capabilities of today. The three areas are however a bit different in the sense of concreteness as well as continuation of improvement. It is interesting when realizing that after a possible implementation of blockchain the Tracking and Transparency areas could lead to new

possibilities. Transactions are in a way not a core for the manufacturing, hence less development potential, while Tracking of the goods could lead to more opportunities in product development and production improvement, maybe even more so regarding the Transparency. However this report is presenting these areas and then future possibilities derived from these areas become mind speculation at this moment.

6.2 Blockchain's innovativeness

What first is notable is the fact that blockchain often are perceived and described as an all-problem solver. The literature and experts diverse a lot depending on what their interest in blockchain is. The conclusion to be drawn is that the potential seems very high but it is not the blockchain itself that will achieve the amount of greatness. It is to be considered as a digital database and communication system that with the right applications can have a great impact on todays strive towards digitalization. There are certainly innovative areas where the ability to exchange information with higher amount of security and trust are two of the main drivers, which allow for more collaboration and communication. It is sometimes mentioned as the new Internet and similarities can be seen in the way that it allows for a new level of communication. Internet in itself does not generate value but the applications and information exchange facilitated by it certainly do.

Back to the innovative areas of blockchain, the more specific innovativeness is probably enabling of smart contracts. Smart contracts is not innovated by blockchain but can reach its potential through it. Both the literature and industrial experts confirm and even celebrates the saved time and administration that it would mean. However considering the other functions, ledger and digital signatures, they don't have innovativeness as a characteristic, they are already existing and merely changing shape with blockchain. However they are a necessity for the blockchain to be able to have potential at all.

The three main functions are also what together will enable the functionalities to be obtained that are desired from manufacturing. The ten functionalities desired by manufacturing are all very much related to the drive behind digitalization, which is the desire for more information and knowledge. This is then positively confirms and further pins blockchain as a possible technology for obtaining digitalization and functioning as the tool to more knowledge and information.

6.3 New technology concerns

That it is a new technology is noticeable throughout the whole research. It creates an interest when researching due to the context of the word new, however it also creates an important aspect to have in mind in order to create a reliable research. It continuously causes thoughts about potential and what is biased and what is not. Furthermore it creates a balance in presenting information that is approximately in the same time in the future. Furthermore it has been important to discuss the implication of implementation of new technology. To have a discussion regarding the disruptiveness will not be done but rather stress the more hidden issues when implementing new technology. The realization of that the issues with implementing blockchain are often forgotten in the literature and therefore it is interesting to bring it up in this report. For example a change towards a blockchain implementation affects the rest of the supply chain as well. If exemplified through usage areas: Transactions will require the other actors to use blockchain, as well as possibly damaging the relationship with the bank when services are transformed. Secondly, tracking will require a new type of relationships with the actors in the supply chain. Blockchain implemented at suppliers will mean additional tasks and openness, which might not be adding to their value creation and it will therefore initially be seen solely as a service for the requiring company. Thirdly, transparency through blockchain might be a threat to other parties in the supply chain. Exposure might also lead to new complicated and threatening negotiation situation when information and processes now are visible. These concerns are related to transactional risks and even though solutions are not discussed in this report it should not be forgotten in the hype of new technology. Furthermore it is important to realize that it is an intercompany change involving large corporations and the agility is therefore lesser than for the promising startups. Internally it is also important when implementing new systems that it is thoroughly anchored among a larger group in the company, otherwise it could result in an unsuccessful result regardless of the potential. Lastly what cannot be stressed enough is that the security aspects of blockchain has to be assured before the blockchain can be used with its potential.

6.4 Sustainability

Sustainability is something discussed through out this research, however not in a concentrated form. This last section of the discussion will therefore elaborate and summarize reasoning regarding sustainability. Elkington (1998) presents a suitable framework to use as a discussion. It states that sustainability can be divided in to environmental, economical and social aspects. These will hereby be discussed and to be noted is that they are discussed from a potential-perspective.

Planet, environmental aspect
The environmental aspects of a technology not implemented or not studied in that way is hard to conclusively determine, however there are matters in this report that could lead to a better environmental impact. With a higher tracking and transparency with usage of blockchain there is a possibility to see if the important fact that environmental certifications are actually followed and a better possibility to get an overview of transportation methods used. However a possibility to collect environmental data is maybe even more promising. Then one actor in a supply chain can theoretically see the overall environmental impact of a supply chain. Hence potentially be able to improve.

Profit, economical aspect
To discuss the economical aspects of this report is too vague. There will be economical shifts, mostly through digitalization and a shift towards a more collaborative environment. However, to speculate about this is hard due to immaturity of the technology and due to the nature of this report. Which is that the impacts are not included in the scope. One can argue that to survive in a new industrial era is a part of profit sustainability and that economical value creation can be increased after a digitalization and usage of blockchain.

People, social aspect
Greater transparency and collection of more data can be used to better social aspects. However it should be noted that usage of blockchain in itself would not create improvement in the social aspect, the same goes for environmental aspects. However ethical work situations are mentioned in literature and believed is that this kind of aspects can be improved. To be able to be transparent regarding a matter that is hard to overview for companies that want to improve in these areas may work as a way for future improvements.

7. Conclusions

This report researched how blockchain can contribute to digitalization of the supply chain. The results show that blockchain in fact is a promising technology that has the potential of contributing to a more developed industry through digitalizing the supply chain.

This report has identified three usage areas where blockchain as a technology will contribute through digitalization:

- **Transactions -** Including banking services in the blockchain will increase efficiency, lower costs and fill information gap about products flow.
- **Tracking -** Blockchain allows companies to better forecast and plan resulting in a more efficient production.
- **Transparency -** Blockchain allows manufacturing companies to be able to improve products, efficiency and sustainability and use it as competitive advantage.

Technology is a key for higher digitalization and here blockchain seem to be a promising solution. The usage areas concretize the potential of blockchain through digitalization. This research also shows that digitalization can improve collaboration, communication, sharing and trust along the supply chain. These are drivers behind digitalization and blockchain is a technology that is connected to these drivers, making blockchain suitable for a digitalization technology. When these drivers are improved more information and knowledge can be obtained and a more efficient supply chain can take form. To visualize the found logical chain see Figure 2.

Figure 2: The logical chain as a result of blockchain used in the supply chain

Digitalization, if not explicitly expressed when researching and interviewing for the report, permeates most of the reasoning behind the impact and desire of blockchain. When evaluating and researching blockchain reasoning like more information, quicker access to information and higher collaboration are possible answers to drive and impact of the technology. These can all be connected to digitalization and therefore the conclusion is that it is in fact a more digital mindset and digital transformation that are desired when discussing drive for blockchain.

The usage areas potential should not be mistaken for that it is a new technology that still is not mature yet to use. The technology is under development and mainly ensuring security while keeping the process time down are the main barriers for future implementation. Furthermore it should not be forgotten that it is a new technology and that means issues to be addressed. The report concludes three important main areas regarding new technology. Firstly general risks of adapting new technology, secondly the disruptiveness and thirdly pitfalls connected to blockchain. The conclusion of this is to remember that the potential of blockchain and the showing of disruptiveness should not blind the companies in focus and stress that risks and pitfalls are always present regarding new technology.

However after this research, through these proven usage areas, the interest from industry and the promising way it is described in literature blockchain can come to play a major role in the future and will grow significantly in importance the upcoming years.

8. References

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8.2 Figure

Figure 1: Gigatribe*, What is peer-to-peer (p2p)?* (2017) Retrieved from https://www.gigatribe.com/en/help-p2p-intro

Figure 2: The logical chain, self made (2017)

8.3 Quotes

Don Tapscott, ***C.M., BA, BSc, MEd, LLD. CEO, The Tapscott Group Inc.***
Associate of the Berkman Klein Center for Internet and Society at Harvard University. Senior Advisor, World Economic Forum. Chancellor, Trent University. Founder and Executive Chairman Global Solution Networks Program.

Bill Gates, *Co-chair of the Bill and Melinda Gates Foundation & Microsoft Corp. Co-founder*

Appendix

Questions for interviewee 1 & 2

Your role?

Describe what you are doing with blockchain technology?

What are the main drivers to why airbus is researching this?

I have found three main areas of usage, what are the main use areas for Airbus?

When can the first blockchain be used?

Is the purpose with blockchain to use internally or sharing with suppliers?

What are the main problems and barriers with it today?

Questions for interviewee 3 & 4

What is your role in the company?

Explain the foundations of SCM from your point of view.

What are the biggest problems today?
- Bottlenecks?
- Lead times?
- Collaboration with suppliers?

What are the new trends within supply chain?

How much do you cooperate with suppliers in terms of knowledge sharing, information exchange etc? Or is it more of a straight buying selling business?

Are you working towards having a closer relationship with your suppliers?

If blockchain would be implemented, what do you think that would do for the supply chain?

More information about products in order to know where products are is that relevant?

Questions for interviewee 5

Your role?

What drives the bank or banks in general to do research about Blockchain?

I research from a manufacturers perspective, which makes banks highly involved when blockchain is discussed. Research proposes that theoretically Blockchain could eliminate the need for a bank, a more realistic step would be to see it as the collaboration would change. How does a bank think about this?

Are there knowledge that is easy to pinpoint that banks have that cannot easily be transferred/replaced to/by the blockchain?

Let's say that blockchain is implemented along a supply chain, trust will increase, is it then realistic to think that the involvement of two banks is reduced?

Is it a very long step for money except digital currencies to be used as payment a long a supply chain using blockchain?

What is realistic regarding the future role of a bank in a supply chain?