# Increased traceability of recycled cardboard and containerboard packaging with the help of blockchain technology

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MASTER THESIS

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# Abstract

Producers in the cardboard and containerboard packaging industry want to, and are sometimes forced to, increase the amount of recycled fibers in packaging, but there is no way to confirm the actual composition of fibers by examining the material optically or chemically. Blockchain technology is often seen as a promising technology for data storage and it is argued that it can help increase transparency through supply chains. Thus, this thesis explores if blockchain or distributed ledger technology, can help the cardboard and containerboard packaging industry and its supply chain to meet the future challenges of traceability of recycled fibers.

The thesis has a descriptive and exploratory approach. It consists of three different phases; one frame of reference study to establish basic knowledge, one literature study to understand the drivers, opportunities and challenges of applied blockchain/distributed ledger technology in a supply chain-context and an interview study to explore the drivers behind increased traceability in the cardboard and containerboard packaging industry.

The results of the studies indicate that neither the usefulness of a blockchain solution nor the ease of using the technology is high enough to implement a blockchain solution in the cardboard and containerboard packaging industry today. Only two out of the three most important drivers for blockchain adoption were present within the cardboard and containerboard packaging industry. Most importantly the main driver, lack of trust, was not present within the industry as actors heavily depend on mutual trust. Compared to physical products in industries, where blockchain solutions have been found useful, not many similarities are shared with cardboard or containerboard packaging. Additionally, the technology itself is complex and there is an absence of common standards for implementation. It would demand a great effort to understand the possibilities of the technology due to the absence of large-scale success cases from other supply chains.

Furthermore, there are conflicting viewpoints as found by this study whether the choice of recycled fiber over virgin fibers does guarantee a more sustainable alternative. Thus, the conclusion is that it would be more appropriate to focus on storing the overall carbon footprint as a sustainability metric instead of recycled fibers and further investigate if blockchain can offer a viable solution for storing such data.

**Keywords:** Blockchain technology, Distributed ledger technology, Sustainability, Supply chain, Recycling, Cardboard and containerboard packaging industry

# Sammanfattning

Producenter inom industrin för pappersförpackningar önskar, och är ibland även tvingade, att öka mängden återvunna fibrer i sina förpackningar. Det finns dock inget sätt att säkerställa den faktiska fördelningen av jungfru- och återvunna fibrer på optisk eller kemisk väg. Blockkedjeteknologin ses ofta som en lovande teknologi för datalagring och spås ha stora möjligheter att öka transparensen genom försörjningskedjor. Därav undersöker denna uppsats om blockkedjor kan hjälpa industrin för pappersförpackningar och dess försörjningskedja att möta framtidens utmaningar gällande spårbarhet av återvunna fibrer.

Denna rapport är av deskriptiv och explorativ natur. Efterforskningarna bestod av tre olika faser; en studie för att bygga upp referensramen för rapporten, en litteraturstudie för att förstå den pågående forskningen inom blockkedjeteknologin och dess applicerbarhet på logistikkedjor samt en intervjustudie för att utforska drivkrafterna bakom ökad spårbarhet inom industrin för pappersförpackningar.

Resultaten av studierna indikerar att vare sig användbarheten av en blockkedja eller lättheten att använda teknologin är tillräckligt hög för att implementera en sådan lösning i industrin för pappersförpackningar i dagsläget. Endast två av tre av de viktigaste drivkrafterna för att implementera en blockkedja i en försörjningskedja fanns närvarande inom förpackningsindustrin. Den viktigaste drivkraften, avsaknad av tillit, saknades då industrin i stor utsträckning bygger på tillit mellan de olika aktörerna. I jämförelse med produkter, för vilka blockkedjor tidigare har bedömts vara passande, finns inte många likheter med en pappersförpackning. Vidare är teknologin komplex och det finns heller ingen gemensam standard att bruka vid implementering av teknologin. Det skulle krävas en gedigen insats för att förstå möjligheterna hos blockkedjeteknologin ty storskaliga implementeringar inom försörjningskedjor saknas och således finns inga fall att lära av.

Vidare råder delade meningar kring huruvida valet av återvunna fibrer garanterar ett mer hållbart val än jungfrufiber. Därav är slutsatsen att det vore mer passande att lagra det totala koldioxidavtrycket som ett mått på hållbarhet istället för mängden återvunna fibrer samt vidare undersöka om blockkedjeteknologi kan erbjuda en lämplig lösning för att lagra sådan data.

**Nyckelord:** Blockkedjeteknologi, Distribuerad huvudboksteknologi, Hållbarhet, Återvinning, Försörjningskedja, Industrin för pappersförpackningar

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To Gunnar Sundblads forskningsfond, thank you for supporting our thesis and giving us the opportunity to travel abroad and participate in three different conferences linked to blockchain and paper technology. The trip greatly contributed to our knowledge acquisition as well as our future interest in exploring the adoption of emerging technologies.

Lastly, we would like to show our gratitude to the fellow students in our seminar group during the last six months. Your opinions and thoughts on our work has improved our final report greatly.

Lund, May 2019

Louise Ragnarsson and Eric Trulsson

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# List of acronyms and abbreviations

| | |
|---|---|
| BCT | Blockchain Technology |
| DLT | Distributed Ledger Technology |
| DoC | Declaration of Compliance |
| LCA | Life Cycle Analysis |
| ICT | Information and Communication Technology |
| IoT | Internet of Things |
| P2P | Peer-to-Peer |
| SCM | Supply Chain Management |

# 1 Introduction

*This Chapter provides a short explanation of the background and the key challenges which form the research questions of this study. Additionally, the purpose as well as restrictions of the study are described.*

## 1.1 Background

Sustainable business practice and extended producer responsibility have received major interest lately, there has been initiatives by individual companies, NGOs, trade organizations, local governments as well as international policymakers to make businesses aware of their environmental impact (SFS 2018:1462; Henderson, 2018). Today, actors seldom have full control nor insight in the complete value chain for their products or services and deriving data from one actor in the supply chain to another is often troublesome (Gao et al. 2018). Large multinational organizations set ambitious goals for how they and their offerings should become more sustainable (Procter & Gamble, 2018; The Kraft Heinz Company, 2018; Unilever, 2019b). Simultaneously the European Union introduces legislation to increase the amount of recycled materials and ban others (European Commission, 2018).

From a branding perspective, large savings can be achieved if organizations work proactively, know their supply chains and extend their responsibility (Wijethilake, 2017). But tracing data and trusting suppliers pose challenges as some goods are fungible, they have material properties that are essentially interchangeable, a classic example is metals. Cardboard and containerboard packaging are also fungible goods when it comes to the distribution of recycled and virgin fibers since they cannot be separated from one another. This is problematic as producers want to, and are sometimes forced to, provide information of the packaging's configuration, but there is no way to confirm the actual composition of virgin versus recycled fibers by examining the material optically or chemically (Anderson, 2019 6th of February, Interview).

To increase the transparency in the cardboard and containerboard industry this thesis aims to do a novel study of how modern technology, specifically how blockchain technology or as some call it, distributed ledger technology (DLT), can support organizations on their mission to become more sustainable. Blockchain technology (BCT) is often seen as a promising for data storage and it is argued that it can help increase asset tracking and transparency through supply chains, reduce transaction costs and facilitate documentation in a more effective way (Wang, Han et al. 2018). Thus, it is interesting to explore how blockchain or distributed ledger technology, can help the industry and its supply chain to meet the future challenges of cardboard and containerboard packaging traceability. As blockchain technology is under development there are discussions of what exactly defines it, one aspect is the name itself, to mitigate this the authors have chosen to use blockchain technology and distributed technology as synonyms which might seem controversial for some enthusiasts. This was done in order to future-proof the thesis and make sure it is accessible as the technology evolves and time passes.

Blockchain or distributed ledger origins from financial applications as it is the backbone of cryptocurrencies like bitcoin. Most other applications have either been theoretical or of experimental nature, but supply chain activities are believed to be among the ones to be transformed in the future by the promising technology (Wang, Han et al., 2018; Kshetri, 2018). Recent research has to a large extent focused on the geographical tracking of goods or the provenance of the goods, to our knowledge, there are no studies that have tried to use BCT to determine the actual composition of a material and trace it through a supply chain.

## 1.2 Definition of key challenge

As a multinational brand owner, it is essential to have extensive knowledge of all aspects of one's offerings as scandals like child labor, introduction of toxins, human rights violation etc. can have great impact on the value of the company and the general view of the organization. Consumers and other stakeholders can hold organizations accountable for misbehavior which might occur outside their own organizational limits. Furthermore, governments introduce more extensive legislation of producer responsibility and thus it is important to in a structured and tamper-proof manner gather data of supply chains with many different actors to establish trust where it might be lacking. Innovative solutions for traceability can become an advantage, as it potentially can enable efficient responses to product or process failures and communicate trustworthy information to all relevant parties (Parmigiani, Klassen and Russo, 2011).

Some parameters might either not be possible or very costly to physically measure or distinguish. Today, it is not possible to separate a recycled wood fiber from a virgin as the appearance of a processed virgin fiber is the same as a recycled one due to the milling process and its impact on the individual fiber. The only possible statements that can be made is that either the cardboard and containerboard packaging contains recycled fibers, as there are residuals from the recycling process which cannot be found in virgin fiber, or that the packaging most likely does not contain recycled fibers as there is no such residuals. Thus, it is principally only possible to state that the packaging is made of only virgin fiber or contains an unknown amount of recycled fiber (Andersson, 2019 6th of February, Interview).

Brand owners set ambitious goals to use recycled material as well as promote recyclable packaging, simultaneously the EU demands increased amounts of recycled packaging (European Commission, 2018). For example, in their press release, The Kraft Heinz Company (2018) state that:

> *"Company Aims to Make 100% of its Packaging Recyclable, Reusable or Compostable by 2025; Increase Usage of Recycled Materials; Pledges to Set Science-based Emissions Reduction Targets".*

Procter & Gamble (2018) state in their press release of their vision for 2030 that:

> *"100% of our packaging will be recyclable or reusable.. We will build even greater trust through transparency.."*

Whereas Unilever (2019b) aims to support increased recycling:

*"Working in partnership with industry, governments and NGOs, we aim to increase recycling and recovery rates on average by 5% by 2015 and by 15% by 2020 in our top 14 countries"*

The main issue though is that there is no way of verifying to what extent a cardboard or containerboard packaging contains recycled fiber. Thus, brand owners struggle to make reliable sustainability strategies concerning recycled material which they can verify and communicate to consumers. Furthermore, it is interesting to know the composition of an individual packaging, both from a branding perspective as well as from a recycling perspective as the information might help to enable better utilization of the product. Therefore, brand owners seek a viable way to increase traceability and its trustworthiness (Anderson, 2019 6th of February, Interview).

Blockchain technology was developed by Nakamoto (2008) as the backbone for the cryptocurrency called bitcoin. The technology is essentially a way to store data in a distributed peer-to-peer system architecture, which means that the database in terms of data and ownership is shared among its users (Dreschner, 2017). Deployment of blockchain technology outside finance has mostly been of experimental nature but supply chain activities are believed to be among the ones to be transformed in the future by the promising technology (Wang, Han et al. 2018). Blockchain technology can be used in a supply chain to know who is performing what actions, at what time and location and thus increase the transparency of the industry (Kshetri 2018).

The technology has inherent characteristics to address issues of inconsistent data and lack of trust and transparency among the many actors in logistics management, issues essential for the success of international trade (Wang et al. 2018). However, the development and diffusion of blockchain technology is still in its infancy, subsequently it is exposed to widespread speculation and both managers and academics struggle with making sense of potential applications of the technology (Wang, Han and Beynon-Davies, 2018).

Consequently, this thesis aims to explore whether blockchain technology with its characteristics can help the value chain to increase the traceability of recycled fibers and trustworthiness within the industry of cardboard and containerboard packaging. The following main research question has been formulated, it is supported by four underlying research questions as they help to address the main one by getting different viewpoints from the industry itself and academia and thus combine different methods of research.

## 1.3 Research questions

Can blockchain offer a viable solution for the value chain of cardboard and containerboard to improve traceability of recycled fibers in packaging?

> *RQ1. What are the main trends in the cardboard and containerboard packaging industry?*
>
> *RQ2. What traceability exists in the value chain of cardboard and containerboard packaging and how does the different actors perceive existing traceability?*
>
> *RQ3. Are there any existing blockchain initiatives within the cardboard and containerboard packaging industry?*
>
> *RQ4. What are the drivers, challenges and threats of implementing blockchain solutions in supply chains?*

## 1.4 Purpose

The thesis is based on an extensive academic literature review, descriptive interviews with experts in blockchain technology and in paper making as well as an explorative interview study with actors from the industry of cardboard and containerboard packaging. Consequently, it aims to provide a scoping of future business opportunities for RISE Bioeconomy. Just as the literature states; managers and academics struggle to make sense of the opportunities provided by blockchain technology, therefore this thesis aims to increase the understanding by examining this specific business case not just for RISE but also for others interested in the research of implementing blockchain technology in supply chains.

## 1.5 Restrictions

This study is explorative and focuses on understanding the cardboard and containerboard packaging business as well as the blockchain technology. Thus, the study consists of a mixture of literature research and qualitative interviews. Different types of actors of the lifecycle for a cardboard or containerboard packaging were mapped and interviewed. For every type of actor in the value chain specific relevant interviewees in larger organizations active on the Swedish market were sought for within representative organizations. However, representatives from all categories were not interviewed since either existing reports were found sufficient or they were not seen as having a large effect on the scope of this thesis. Firstly, there already exists extensive research of consumers attitudes of packaging and recycling, as for example by Procarton (2018), and it was believed to be sufficient to use this as a base. Secondly, distributors were not perceived to be interested in the type of traceability that is the aim of this study since they do not affect the physical composition of the cardboard and containerboard packaging. In contrast product fillers who, like distributors, does not directly affect the composition of packaging were perceived to have a greater interest and were thus included in the study.

Parts of the value chain are global since chosen actors are often not only active on the Swedish market, but the report focuses on the Swedish market.

Finally, this study does not seek to develop a specific blockchain solution for how to trace recycled fibers in cardboard or containerboard packaging in its life-cycle but rather explore if it is of interest for actors in the value chain or even possible, and if so, evaluate if blockchain might offer features that suit the needs.

# 2 Method

*This Chapter describes the methodology used for the project. First, the general research design is specified, then the different phases are described more thoroughly. The last paragraph of the Chapter discusses how the quality of the study is ensured.*

## 2.1 Research design

The overall purpose of a thesis can be described as descriptive, explanatory, exploratory or problem solving and generally a project does not only have one purpose but rather a mixture of them (Höst, Regnell and Runeson, 2006). To be able to answer the stated research questions and fulfill the purpose in Chapter 1.4, this thesis aims to be both descriptive and exploratory. The thesis describes cardboard and containerboard packaging manufacturing and its industry as well as blockchain technology. It aims to explore the perception of existing traceability and potential drivers for increased traceability in the cardboard and containerboard packaging industry. It also seeks to explore whether blockchain may be a viable solution to solve the identified traceability challenges. As the project explores a field characterized by its novelty the research design benefit from being somewhat flexible to provide opportunity for new discoveries and insights during the study (Kothari, 2004).

The thesis rests on three different phases of research as seen illustrated in Figure 2.1. Due to the explorative nature of the thesis the steps were done in conjunction and iteratively and were not strictly separated in time. But overall, each step received focus according to the order illustrated in Figure 2.1 Thus, the three steps are illustrated as they follow each other in time but they are interlinked with arrows to show how flexibility was built into the thesis' workflow as a way to provide opportunities to adapt the research to new discoveries and insights.

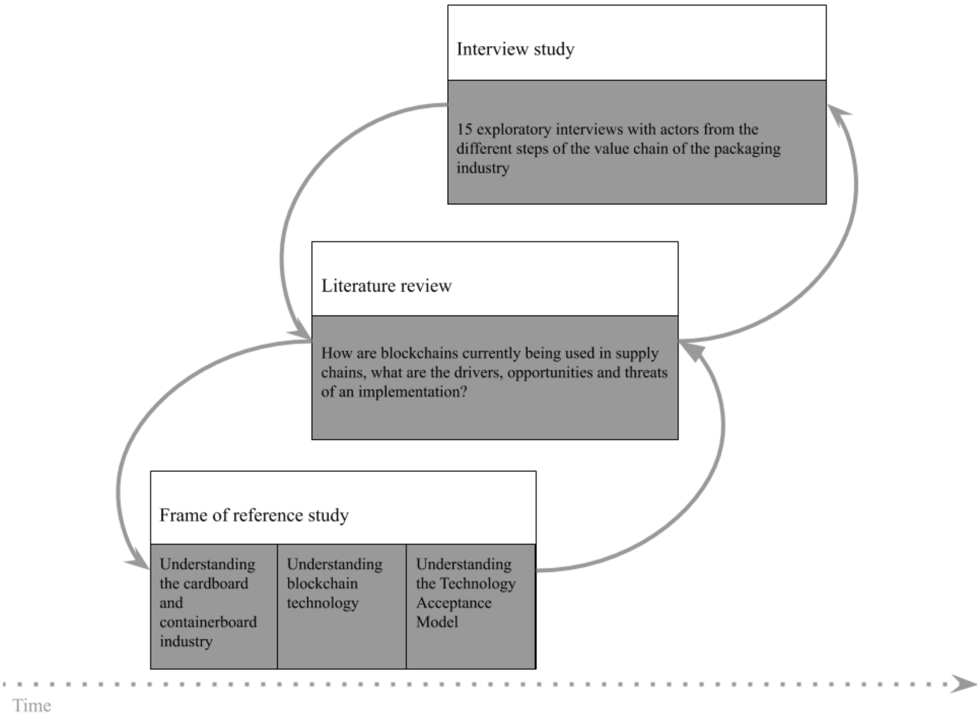


**Figure 2.1 Illustration of the research design**

The first step which is called *Frame of reference study* aimed to make the authors familiar with the different core concepts essential for the foundation of the thesis. Thus, the first step focused on understanding paper production, the circular value chain of cardboard and containerboard packaging, existing certification, what blockchain is as well as the Technology Acceptance Model by Davis (1989). At this initial step the databases available to students and employees at Lund University (LUBsearch) were searched for peer reviewed published articles focusing on blockchain or distributed ledger technology and packaging combined with sustainability, recycling or certification. This generated a total of six articles, thus, the authors realized that the specific area of interest is not explored to a wide extent.

Consequently, it was decided that the scope for literature searches was needed to be lifted a level and rather focus on the application of blockchain/distributed ledger technology on supply chains and traceability. It seemed appropriate to focus on supply chains in general since parallels between the cardboard and containerboard packaging industry and other types of industries may be drawn. As it was searched for literature that combined BCT/DLT with supply chain the article *Understanding blockchain technology for future supply chains: a systematic literature review and research agenda* written by Wang, Han and Beynon-Davies (2018) was found. This was the only systematic literature review of the field which the authors of this thesis came across and the article helped to form a base for further research.

The finding of the above-mentioned review moved the research into its second step, a literature review following the same principles as conducted by Wang, Han and Beynon-Davies (2018) to understand the state-of-the-art research of applied BCT/DLT in a supply chain-context as the area is rapidly expanding. A more thorough explanation of how this literature review was conducted can be found in the Chapter with the same name.

As the authors managed to establish a basic understanding of the cardboard and containerboard packaging industry and blockchain technology from step one and two, phase number three was initiated. This step mainly consisted of 15 qualitative interviews with actors of the identified value chain for cardboard and containerboard packaging. The list of interviewees can be found in the appendix B. Here the authors used an interview guide, found in the appendix C, to collect data in a unison manner and enable objective analysis of the input data.

All the different steps of the thesis helped to answer the four underlying research questions which in order helped to support a discussion of the overall research question of whether blockchain can offer a viable solution for the value chain of cardboard and containerboard to improve traceability of recycled fibers in packaging. By combining the different steps of the research and their respective methods to answer the four questions respectively it was ensured that the main question got analyzed using different methods. The frame of reference-phase set the foundation for understanding. The literature review aimed to answer RQ4 of what the drivers, challenges and threats of implementing blockchain solutions in supply chains are. The interview studies focused on RQ1, RQ2 and RQ3 as it consisted of qualitative interviews with actors from the industry of cardboard and containerboard packaging. Below is a conceptual visualization, Figure 2.2, of how the different phases of the research corresponds with the different research questions of the thesis and how they create the understanding provided by this thesis. More thorough explanations of each step of the research can be found below.

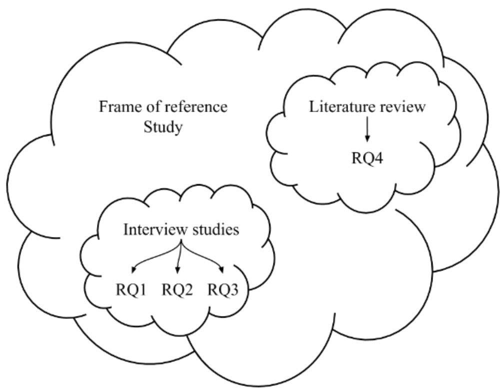


**Figure 2.2 Conceptual illustration of links between research phases and research questions**

### 2.1.1 Frame of reference studies

This initial phase served as the semantic foundation for the thesis and consisted of three different areas of research, the cardboard and containerboard packaging industry, the blockchain technology and the technology acceptance model which served as a theoretical framework when analyzing the results.

To gain an understanding of the cardboard and containerboard industry and the blockchain technology a number of 13 descriptive interviews were conducted, a list of the interviewees can be found in the appendix A. The interviews were mainly conducted with individuals within different relevant departments of RISE, the Swedish Standards Institute (SIS) and blockchain experts from IBM and the European Blockchain Association. The interviews helped the authors to collect material in terms of literature, pinpoint the thesis and support the thorough understanding which is provided in the frame of reference Chapter. According to Höst, Regnell and Runeson (2006) structured questions are to be preferred when interviewing for descriptive purposes. However, a risk of using structured questions is to miss out on important information on the topic which led to the conclusion of using semi structured questions adapted to each interview.

To establish a basic knowledge of blockchain technology, additionally to the interviews, the authors read articles, industry white papers and the two books *Blockchain Basics* by *Daniel Drescher* and *Blockchain revolution: how the technology behind bitcoin is changing money, business, and the world* by *Tapscott and Tapscott*.

The authors also participated in three different conferences. Two conferences within the field of blockchain to understand the state of the art; ANON Blockchain Summit in Vienna and Blockchain Summit in Frankfurt. The third conference focused on the state of art in the paper industry; International Munich Paper Symposium.

The technology acceptance model was mainly explored by reading literature written by the developer Davis (1989).

### 2.1.2 Literature review

At an early stage it was understood that blockchain technology is still in its infancy and most of the research and applications focus on cryptocurrencies, but the area is expanding rapidly due to a large hype. Since there was not much academic literature focusing on blockchain or distributed ledger technology and packaging combined with sustainability, recycling or certification the search was broadened to rather focus on supply chains.

To utilize current knowledge in the field of blockchain and its applicability on supply chains a literature review was conducted. The purpose of the review was to map how blockchains are currently being used in supply chains and what the drivers behind implementing blockchain in supply chains are. In early 2018 a literature review on this very topic was published; *Understanding blockchain technology for future supply chains: a systematic literature review and research agenda* written by Wang, Han and Beynon-Davies (2018). This review used articles published between 2008 and 2017 which were retrieved from nine different academic databases (*ABI Inform Global, Emerald, IEEE Xplore, JStor, Science Direct, Scopus, Springer, Taylor* and *Francis and Web of Science*) as well as practitioner literature.

Since blockchain is an expansive field of research, due to its novelty, an even more up to date review of literature was conducted by the authors. This review searched the same databases as Wang, Han and Beynon-Davies (2018) and used similar search terms *Blockchain, Distributed ledger* combined with either *Supply Chain* or *Chain of Custody*. The search terms were mildly altered to better suit the scope of this thesis. Only articles published between January 2018 and January 2019 were selected since the "older literature" was assumed to be covered in the article by Wang, Han and Beynon-Davies (2018).

To gather relevant information for a literature review different approaches can be used. In this review citation pearl growing was used which means starting from one document and use suitable terms in that document to retrieve other documents. Furthermore, blocks were built by customizing the search words by using synonyms and extended terms. To reduce the amount of included literature successive fractions were made by reading abstracts and eliminate literature with too weak connections to either blockchain or the supply chain in the cardboard and containerboard packaging industry (Rowley and Slack, 2004).

The chosen search words generated a total of 308 results, which is noticeably more than the 227 that Wang, Han and Beynon-Davies (2018) acquired for the period between 2008 and 2018. All generated articles were not relevant and those that did not focus on supply chains were excluded, for example, some articles only focused on cryptocurrencies which was not perceived as relevant for the study conducted. A screening process was composed of three different filters in order to select the most suitable results, just as Wang, Han and Beynon-Davies did. Firstly, duplicates were eliminated, secondly, all papers were screened based on their types and titles and studies that were not relevant to the scope of the mapping in this study were excluded. Thirdly, the abstracts of each remaining paper were read and the non-relevant articles were rejected. At the end a total of 19 articles were chosen and read thoroughly to identify key drivers, opportunities and threats for the implementation of blockchain technology in different supply chains. When all articles were read through the results were clustered to more general categories. It was decided that the main drivers, opportunities and threats had to be mentioned in at least two of the total 19 articles to be included in the result, which can be found in the results Chapter.

### 2.1.3 Interview studies

According to Höst, Regnell and Runeson (2006), an interview study is one type of case study which aims at providing in depth knowledge and the method is flexible since the questionnaire can be modified as the study proceeds. In comparison with doing a survey, an interview study does not provide any evident or statistically ensured results since it is not based on a random selection of cases like in a survey. Since the project explores a novel field a flexible method was found appropriate, thus the interview study method was found viable. To increase the possibility of identifying general patterns several interviews were conducted.

The interview study consisted of exploratory interviews with actors from the different steps of the value chain of the cardboard and containerboard packaging industry. The 15 interviews explored what drivers are present within the industry, who perceive them, what opportunities are available as well as what specific factors of the industry might hinder a possible blockchain deployment to increase transparency. Literature on the adoption of BCT within the supply chain context is limited to a handful of case studies within industries that vary greatly. Consequently, the findings of the cardboard and containerboard industry in this thesis was compared with the general features of blockchain adoption in supply chains according to the findings in the literature studies.

According to Höst, Regnell and Runeson (2006), open ended questions are recommended when interviewing for exploratory reason and was thereby used in this part of the study.

The interviews were conducted in-person, via telephone or via email. Different methods were used for different individuals because of geographical restrictions as well as the fact that some interviewees had limited time available. It has been of importance to talk to at least two different actors from each identified step of the of the value chain.

To analyze the interviews, it was sought for commonalities and differences in statements made by the different interviewees which were used to codify the results. These findings were then compared to the literature review described in Chapter 2.1.2. Conclusions have not been made upon the opinion of one unique interviewee but rather the aggregated information provided by coding of the respondent's answers.

## 2.2 Quality of the study

To address the overall quality of a project Höst, Regnell and Runeson (2006) suggests that three different categories may be assessed:

1. Reliability – The trustworthiness of the data collection and the analysis of the data, i.e. if the study could be conducted again with the same result
2. Validity – If the study measures what it aims to measure
3. Generalizability – If the conclusions of the study could be used in or be relevant to other research

### 2.2.1 **Reliability**

To achieve a high degree of reliability a thorough description of the method is included in the report. This to give the reader a possibility of evaluating the trustworthiness of the report. The report was also continuously reviewed by the supervisors with the aim of finding areas of the analysis and discussion that needed a more solid foundation. Furthermore, to ensure the reliability of the collected data, the interviewees were presented with their given information included in the report so that they could confirm its accuracy. To further ensure the reliability of this study the quality of the results was analyzed and evaluated by applying the technology acceptance model. This model forms the basis of the discussion in this report. The perceived usefulness of deploying blockchain is elaborated on as well as the perceived ease of using the blockchain technology.

### 2.2.2 **Validity**

The foundation of this report is based on literature studies which in turn were confirmed by conducting qualitative interviews with experts in blockchain technology and paper making as well as actors in the cardboard and containerboard packaging industry. The literature study only peer reviewed literature was used. The interview study was conducted with different actors of the value chain of the cardboard and containerboard packaging industry to accomplish a comprehensive coverage of the entire industry and its different opinions. By using this methodological triangulation, collecting information in this two-phase system, it is perceived that the validity of the study is ensured.

The exploratory interview study is appropriate to help answer research question 1, 2 and 3; *What are the main trends in the cardboard and containerboard packaging industry?, What traceability exists in the value chain of cardboard and containerboard packaging and how does the different actors perceive existing traceability?* and *Are there any existing blockchain initiatives within the cardboard and containerboard packaging industry?* This since the existing trends, initiatives, traceability systems and potential need for improvement are best explained by different actors in the value chain and therefore an interview study is suitable.

The conducted literature study is appropriate to help answer research question 4; *What are the drivers, opportunities and challenges of implementing blockchain solutions in supply chains?* The study explores what kind of incentives, challenges and possibilities, concerning implementing a blockchain in different industries, that have been identified in former academic literature. The findings were used to make comparisons with the cardboard and containerboard industry and thereby reflect upon blockchain's appropriateness in the industry.

Together the four research questions help to answer the main question; *Can blockchain offer a viable solution for the value chain of cardboard and containerboard to improve traceability of recycled fibers in packaging?*

A validity issue in this specific report is the novelty of blockchain and its link to sustainability, certification and more specifically the cardboard and containerboard packaging industry. The amount of research is scarce, and the authors have thus searched for research in adjacent fields such as the use of blockchain in chain of custody and supply chains. Moreover, there is no unanimous definition of the blockchain technology and other words like distributed ledger is sometimes used in research to describe the same concept. The risk of missing important research due to the lack of one common word to describe the technology has been mitigated by using both distributed ledger and blockchain technology as search terms. Also, the authors have included a definition of the blockchain technology based on descriptions from other research to elucidate the meaning of the concept in this specific report. The definition used in this report may not be accurate in the future depending on the direction of future developments of the technology.

### 2.2.3 Generalizability and transferability

This study focuses on the cardboard and containerboard packaging industry and the potential of blockchain in that specific value chain. However, the drivers, opportunities and challenges of blockchain may be related to and compared with other manufacturing industries increasing the generalizability of the study. As a result, the contribution of this thesis suggests future research of BCT and its applicability in storing sustainability metrics, as for example carbon footprint which may be applied outside the cardboard and containerboard packaging industry.

# **3** Frame of reference

*This Chapter describes the theoretical frame of reference for the project based on a literature study and descriptive interviews. The cardboard and containerboard industry, existing certification for forest products, the concept of chain of custody and the blockchain technology are described separately.*

## 3.1 The cardboard and containerboard industry

*This Chapter specifies the different actors in the value chain of the cardboard and containerboard industry, portrays how paper is manufactured and describes the process of recycling paper. It also elaborates upon consumers purchasing decisions and the sustainability of paper production. Lastly, existing certification standards are described.*

### 3.1.1 **The value chain of cardboard and containerboard packaging**

The value chain of cardboard and containerboard packaging is in this project described as a chain that consists of nine different actors, see Figure 3.1. Some actors naturally belong to several steps of the value chain, for example a paper manufacturer may be self-sufficient in wood. In the value chain depicted in Figure 3.1 the paper manufacturer receives virgin wood fiber from the forestry and recycled fibers from a waste recycler. Paper is then sent to the box manufacturer who produces the package and then delivers it to the product filler. The package is then distributed to the retailer or in some cases directly to the consumer. The chain come full circle as the waste recycler collect the used packages and store it on bales to later sell it back to the paper manufacturer. In Figure 3.1 trade organizations and service providers are also represented. These types of organizations represent the interests of the industry across Sweden, Europe and the rest of the world. Issues addressed may be waste management, technical topics or economical questions (Anderson, 2019 6th of February, Interview).

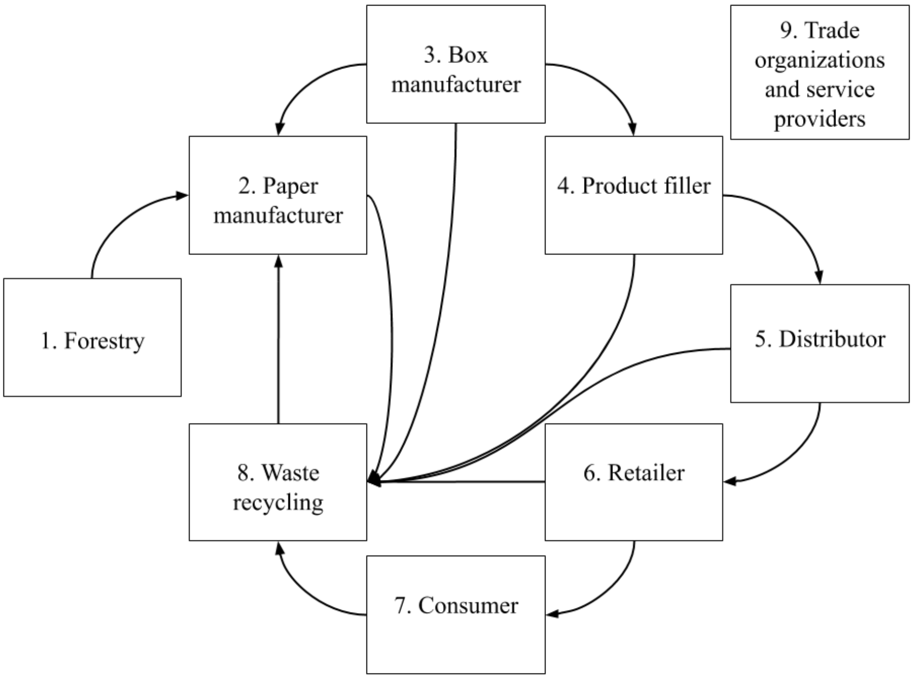


**Figure 3.1 The value chain of cardboard and containerboard packaging**

### 3.1.2 **Paper production**

The main principle when producing paper from wood is that cellulose fibers are separated which can be done by either mechanical or chemical processing. Both processes begin with bark being removed from the logs by rubbing them against each other in a barrel. In the mechanical process logs are pressed against rotating grindstones sprinkled with water. In this process all the components of the log will be included in the pulp and by using grindstones the fibers become comparatively shorter which results in a paper with lower shear strength. To achieve higher shear strength, and thus also higher quality, the chemical process must be used. In this case all components except the cellulose are disentangled by boiling the wood as chips in a solution of water and chemicals. The chemical process results in some useful byproducts, among them the lignin which may be used as an adhesive as well as for incineration. The pulp received from the chemical process consists of almost only cellulose which makes it highly durable. When the mass of fibers is produced the pulp is washed, filtered and then in most cases bleached. When bleached, the pulp is poured on a canvas where water is removed before the pulp moves through heated cylinders to dry and turn in to the actual paper (Andersson, Sonesson & Vannerberg, 1989).

The distribution of virgin fiber versus recycled fiber depends on the paper manufacturer and what kind of paper that is being produced. Some paper manufacturers mix recycled fibers with virgin fibers to attain cost reductions while others use some virgin fibers added to recycled ones to strengthen the quality of the paper. By using water mills the recycled paper is decomposed, the wood fibers float up to the surface while debris like staples sink to the bottom and thereby can be removed. Ink and chemicals can be removed or left in the pulp, it is called ashes and will eventually give the fibers impaired quality and a grey color (Anderson, 2019 6th of February, Interview).

### 3.1.3 **Paper recycling**

The term recycled paper includes all types of paper that is collected and recycled; newspapers, books, carton, corrugated cardboard and paper waste from production. To be able to supply the demand of different types of paper the use of recycled paper is essential (SkogsSverige, 2013). In Sweden 82% of all supplied paper is recycled, in spite of this Sweden has to import recycled wood fiber to cover the demand (SkogsSverige, 2012). Fiber from wood can be recycled up to seven times depending on its origin. The quality of the fiber changes when it is recycled which affects the quality of the final product. Most often the recycled wood fiber is mixed with virgin wood fiber to achieve desired quality (SkogsSverige, 2013).

In 1994 Sweden introduced a regulation to ensure producer responsibility in some selected industries and among them the paper industry. The producers in this regulation are either the manufacturer of a package that is filled at the point of sale, fillers of packages that are filled before point of sale or importers of already filled packages. The responsibility demands that the producer has a process for collecting and recycling what they have delivered to the market (SkogsSverige, 2013).

According to the producer responsibility a producer should see to it that the packages:

1. Has a volume and weight that is limited to the minimum level needed to sustain the level of security and hygiene
2. Can be reused or recycled
3. Are sustainably produced

A package shall be able to recycle by:

1. Using the material or part of the material in a new package
2. Extracting energy from the waste
3. Composting it if it is biologically decomposable

The regulation has been revised several times since 1994 and on January 1st, 2019 the latest version (2018:1462) became effective (Naturvårdsverket, 2019).

In SFS 2018:1462 it is stated that before the first of January 2020 at least 65% of all packages made from paper, cardboard or corrugated paper has to be recycled and thereafter at least 85%. Once a year every actor, that is considered as a producer according to the regulation, in Sweden is obliged to hand in a report to Naturvårdsverket that states what number of packages that was delivered to the Swedish market the past year. If a producer report is overdue a sanction fee of 10 000 Swedish crowns must be paid (SFS 2012:259). According to SFS 2018:1462 a product is a package if it has been produced to either include, protect or present an item or be used to deliver another item. In the regulation four different types of packages are described:

- Consumer package - a package that is part of the final offer for the consumer
- Group package - a package that at the retailer includes more than one item that can be removed without affecting the remaining items
- Transport package - a package that facilitates the handling and transporting of items
- Service package - a package that is filled at the point of the actual selling of an item

Apart from the EU regulations regarding the amount of recycled paper used in the packaging industry the EU Timber Regulation came into effect in March 2013. The purpose of the timber regulation is to prevent trade with illegal timber on the EU market. Before a company places a product made from timber on the market it has to be ensured that the harvesting was conducted according to a legal process and that it was exported legally (Regulation EU. No 995/2010). This regulation is not applicable on recycled paper which means that origin and legal aspects are disregarded when trading recycled paper (European Commission, 2019).

### 3.1.4 **European Consumers Packaging Perceptions**

In 2018 Procarton, the European Association of Carton and Carton board manufacturers, conducted a study which aimed at exploring the importance of sustainability on consumers purchasing decision when it comes to packages. 7000 consumers were surveyed in France, Germany, Italy, Poland, Spain, Turkey and United Kingdom. The study presents figures which shows that the attitude of the consumers to a great extent is focused around sustainability. This puts pressure on the retailers and in turn also the packaging producers to produce environmentally friendly packages. In the study 52% of the respondents stated that they the last 12 months to a greater extent had been seeking for products in environmentally friendly packaging. When asked about different packaging features and their respective importance "protecting the product" is the most highly ranked attribute. In second comes "easy to recycle". Overall 75 % of the consumers answered that the environmental impact of a product's packaging affects their purchasing decision. However, 71 % of the respondents experience a lack information about how to make environmentally friendly decisions and wish government guidance to help them make the right decision (Procarton, 2018).

### 3.1.5 Sustainability of virgin and recycled fibers

There is still a difference in opinion whether recycled fibers are more sustainable than virgin fibers. A common metric used when measuring sustainability is the carbon footprint which is defined as the total carbon dioxide emissions caused by and an individual product. Often it is argued that the collection of materials for recycling requires more energy and consequently generates larger releases of pollutants, and thereby a greater carbon footprint, than the collection of waste for landfills or incinerators. The Paper Task Force (1995) identified that predominant needed energy for the physical production of all grades of virgin and recycled fiber is by far the largest use of energy for the whole process and that materials and residuals collection, processing and transport are all relatively small in comparison. Furthermore, recycling extends the fiber base and can help to conserve forest resources since more trees could be managed to longer rotation to meet demand and can thus help foster environmentally beneficial forest management with increased biodiversity.

Damgaard et al. (2015) made a retrospective analysis of the climate benefits of material recycling in Denmark, Norway and Sweden. The analysis is based on a so-called attributional approach which means that needed electricity for processing the recycled material is produced from a mix of different sources (hydro, nuclear, fossil etc.). The study shows that carbon footprint is lower using recycling alternatives. Interestingly, there is a relatively small difference using virgin or recycled alternatives for paper and cardboard as compared to other materials, but according to the study this is related to the assumed share of fossil energy, hence, the source of the needed energy for the process greatly affects the sustainability of the recycling process.

To problematize further Miranda, Concepcion Monte and Blanco (2013) argues that carbon footprint of the recycling process increases for materials that are sensitive to contaminants. For example, if recovered material from commingled collection exists in many different chemical and physical entities which are difficult to separate into specific fractions, then the emissions will increase. This problem is specifically evident for paper fiber whereas other materials like glass and metals can be remanufactured more easily even with some contaminations. Of course, the requirements of the material affect how “contaminated” it can be, but what is essential to understand is that the sorting and removal of contaminants also affects the climate impact of the recycling process.

As described earlier, depending on how one wish to use the fiber material different methods are needed for processing the material. Graphical paper used for writing and printing consists of wood fibers where the lignin which occurs naturally in the raw material has been removed through chemical pulping to produce a high-quality product. The lignin, which is removed can be used as a bioenergy, both thermal and electric and supply the mills energy needs. This is a process that the Swedish paperboard manufacturer Iggesund uses at their mill in the town with the same name (Iggesund 2019).

# 3.2 Certification

*This Chapter outlines the different types of certificates and standards used in the cardboard and containerboard industry.*

### 3.2.1 **FSC and PEFC**

In the packaging industry two different certificates exist which declare that the wood used in the packages has been desolated from forests that meet social, ecological and economic rights and needs of the present generation without compromising those of future generations. These two different certification organizations are called The Forest Stewardship Council (FSC) and Program for the Endorsement of Forest Certification (PEFC). Within FSC and PEFC a recycled label has been introduced to recognize the importance of recycling but the main purpose of the two organizations are to ensure sustainable forestry.

For a product to be claimed FSC certified all the different organizations in the value chain must be certified by FSC-accredited certification. There are different types of FSC output claims which are based on the type of input in the product. As shown in Figure 3.2 the output claim considered to be most rigor is FSC 100% which is a claim for products based on inputs exclusively from FSC-certified natural forests or plantations. FSC Mix Credit or FSC Mix x% are claims for products based on inputs that to some extent consist of material that is not labeled with FSC 100%, it could for example be recycled paper. FSC controlled wood is material from acceptable sources that can be mixed with FSC-certified material in products with the FSC Mix label (FSC-STD-40-004 (V3-0)).

FSC and PEFC share many similarities, PEFC also has different output labels; one called “PEFC Certified” for products where at least 70% of the wood is from PEFC-certified forests and one called “PEFC Recycled” where at least 70% certified material is from recycled sources (PEFC, 2019). FSC was established in the 1990s and its standards originally focused on the environmental impact in tropical environments, furthermore FSC was in its early days more adapted to large forest owners whereas PEFC aimed at small scale forestry. Thus, a pair of European countries took the initiative to develop the certificate standard of PEFC. Today the differences between the two organizations are fewer, but FSC is more bureaucratic (Jönsson, 2019).

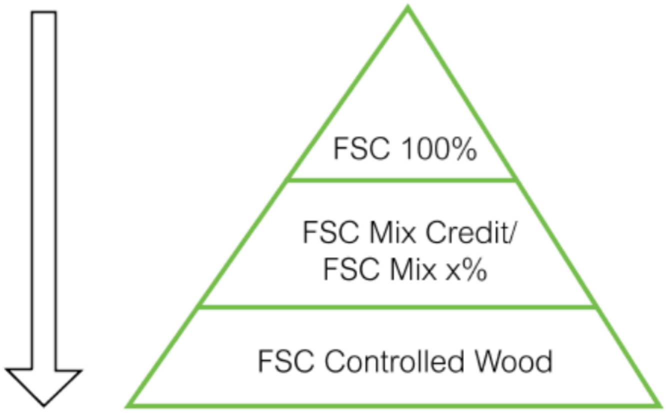


**Figure 3.2 Illustration of different qualities of wood according to the FSC standard (FSC-STD-40-004 (V3-0)).**

### 3.2.2 **Chain of Custody**

To maintain control on the movement of products throughout the supply chain a chain of custody standard is often system set. The system defines requirements and measures to ensure sustainability in every stage of the supply chain and it can be seen as the basis for any claims that can be made about the product. Several different chain of custody models exist since a system to track the movement of a product can be formed in different ways (ISEAL Alliance, 2016).

#### ***3.2.2.1*** *Identity preservation*

In an identity preservation model, it is ensured that certified products are kept separate from non-certified products. This model provides the possibility to trace the certified product from production until end-use. Material with different types of certificates cannot be mixed in this model (ibid.).

#### ***3.2.2.2*** *Segregation*

The segregation model is almost similar to the identity preservation except from the fact that mixing of certified products with different origin is allowed in the segregation model (ibid.).

#### ***3.2.2.3*** *Mass balance*

There are different types of mass balance models but common for all of them are that the same volume of certified products that enter the process can be sold as certified. What differs between the different types of mass balance models are whether physical mixing of certified and non-certified products occur and at what stage of the process the mixing takes place. Below are three different mass balance models described (ibid.).

##### 3.2.2.3.1 Batch-level mass balance

In this model certified and non-certified products are not mixed until the blending of a batch of a product. The proportion of certified material is known for each final product (ibid.).

##### 3.2.2.3.2 Site-level mass balance

In this model the certified and non-certified products are mixed on a site level which ensures a certain amount of certified material leaving the site, but it cannot be decided what proportion of certified material each product contains (ibid.).

##### 3.2.2.3.3 Group-level mass balance

The group level mass balance that mixing of certified and non-certified products can be mixed at any stage of production. If a company owns several sites this can be referred to as a group and in this case the proportion of certified material that enters and leaves the group is known but the proportion for each site and each product remains unknown (ibid.).

#### ***3.2.2.4*** *Certificate trading*

In certificate trading, there is no control of the flow of certified versus non-certified products. Instead a certificate is issued by a third party in the beginning of the supply chain. This model is used by actors to prove that they are working in a sustainable manner but there is no physical traceability throughout the supply chain (ibid.).

## 3.3 Blockchain technology

*This Chapter explores and explains blockchain technology since it is essential to understand the unique features of the technology to evaluate whether blockchain could offer a promising solution for traceability of recycled cardboard and containerboard packaging.*

### 3.3.1 **Definition and characteristics**

The blockchain technology was originally developed by Nakamoto (2008) as the foundation for the bitcoin cryptocurrency. Deployment of blockchain technology outside finance has mostly been of experimental nature but supply chain activities are believed to be among the ones to be transformed in the future by the promising technology (Wang, Han and Beynon-Davies, 2018; Kshetri, 2018). When describing blockchains the following four different characteristics are typically used (Li and Wang, 2018):

1. *Decentralization* – all nodes on the network are equal which means that there is no centralized management organization. Since the database is decentralized and copies of the data is stored on all different nodes the risk of losing data due to a failed database is avoided.
2. *Transparency* – the data on the blockchain is accessible by any node of the network which makes the information on the chain transparent.
3. *Autonomy* – all decisions made on a blockchain is based on consensus. This way data can be transferred in a safe way without the need of trusting a human, instead the technology is trusted.
4. *Tamper-proof* – once information is verified it is permanently stored on the blockchain. Since all blocks added to a blockchain build on each other it is impossible to change the previous data.

Essentially, a blockchain is a technology used to store data. The data of the system is stored in a *distributed peer-to-peer* (P2P) system architecture. A distributed database can be seen as the antipode of a centralized database, the difference between the two systems can be seen in Figure 3.3.

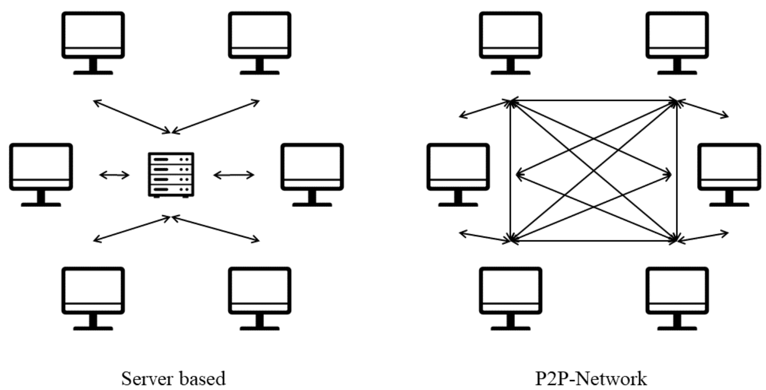


**Figure 3.3 Server based centralized system versus P2P-Network**

Peer-to-peer systems consists of *nodes* which makes their computational resources available to the entire system. Users of the P2P system thus turn their computers into nodes as they join the system which makes their computers both suppliers and consumers of the available resources in the system. The purpose of the blockchain is to achieve and maintain *integrity* in distributed systems, this means ensuring data, which is complete, correct, free of contradictions, that the system behaves as it is intended to and that data is available to authorized users only. In short, a purely distributed peer-to-peer system can use a blockchain for achieving and maintaining integrity of the system. This is interesting since purely distributed peer-to-peer systems can replace centralized systems due to what is called disintermediation, and the blockchain is a means to achieve that removal of intermediaries (Drescher, 2017).

### 3.3.2 Different types of blockchains

Blockchains can be divided into three different types of systems depending on its characteristics; public blockchain, private blockchain and consortium blockchain. In a public blockchain every node has read access as well as the right to take part in the process of reaching consensus on what data should be stored on the ledger. In a private blockchain a preselected group of nodes from one organization are allowed to read and create new transactions. A consortium blockchain is similar to a private blockchain but preselected nodes can derive from different organizations. The public blockchain is more resistant against tampering of data since every node is independent, however, the efficiency suffers since it is time-consuming to append blocks, expand the database, when there are many nodes. With a limited number of nodes, the level of immutability is, on the other hand, decreased but the efficiency increased. Table 3.1 summarizes the main differences between the different types of blockchains (Zheng et al., 2017).

**Table 3.1 Comparisons of Public blockchain, Consortium blockchain and Private blockchain (Zheng et al., 2017)**

| Property | Public blockchain | Consortium blockchain | Private blockchain |
|---|---|---|---|
| **Consensus determination** | All miners | Selected set of nodes | One organization |
| **Read permission** | Public | Could be public or restricted | Could be public or restricted |
| **Immutability** | Nearly impossible to tamper | Could be tampered | Could be tampered |
| **Efficiency** | Low | High | High |
| **Centralized** | No | Partial | Yes |
| **Consensus process** | Permissionless | Permissioned | Permissioned |

### 3.3.3 Asymmetric cryptography

Nodes of a blockchain interact using asymmetric cryptography. Every node has one public and one private key which are used to encrypt and decrypt data on the blockchain. In asymmetric cryptography the cypher text created with one of the keys can only be decrypted with the other key and vice versa, see Figure 3.4 (Drescher, 2017).

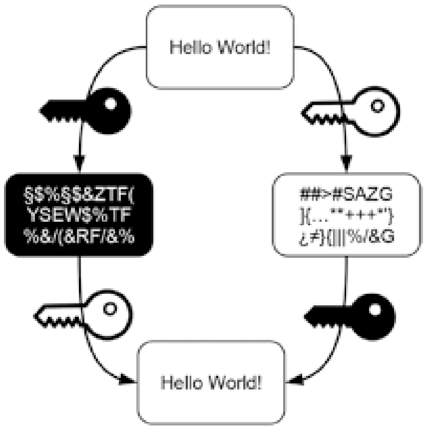


**Figure 3.4 Private and public key (Drescher, 2017)**

The public key is accessible for all the nodes on a blockchain while the private key is kept safe and personal. By using the public key to encrypt data the owner of the complementary private key is the only one who can decrypt and read the data. This public-to-private approach works like a post box, everyone can submit information to the recipient but only he or she can open the messages. The opposite approach, private-to-public, is used to authorize transactions. A node hands off ownership of some data by creating a cypher text with its private key and by using the complementary public key the other nodes indeed know who sent what assets and can therefore verify the proof of the transfer of ownership via the generated digital signature (Drescher, 2017).

### 3.3.4 **Hash functions**

A blockchain uses something called hash functions to assure that data are not changed after it has been stored in the database. A cryptographic hash function transforms any kind of input data into a fixed length output, the output is often called hash value. A function needs to satisfy the following properties to qualify as a cryptographic hash function (Smart, 2003):

- *Preimage resistant:* It should be hard to find a message with a given hash value. This means that it must be a one-way function which makes it impossible to trace the input by its output.
- *Collision resistant:* To find two messages with the same hash value should be very challenging. If the chance of receiving the same hash value from different input is small, then the function is collision resistant.
- *Second preimage resistant*: Given one message it should be hard to find another message with the same hash value. This may sound as collision resistance but the difference between the two is the situation of protection.

> Instead of protecting against two messages by accident getting the same hash value the second preimage resistance protect against malevolent users that tries to steal another's identity.

Every added block contains a hash reference to the preceding block making it a chain of blocks; thus, it is called a blockchain. Since every new block that is added to the blockchain is dependent on all its preceding blocks it is impossible to alter data without detecting it. To verify whether data has been changed a hash value of the concerned data is recreated and compared to the hash value created in the past. If the two different hash values are not identical it is proved that the data has been altered (Drescher, 2017).

### 3.3.5 Consensus mechanisms

To add a block to the chain the different nodes of the network need to reach *consensus* regarding what data is valid. To reach consensus on what information should be stored on the blockchain different mechanisms can be used to align the information of the different individuals.

The proof of work mechanism can be seen as the most classic consensus mechanism as it is used for bitcoin. This mechanism creates something called hash puzzles that requires computational resources to be solved. Nodes in the network receives information of a transaction which needs to be verified and stored on the chain. To verify the transaction the so-called miners, who are essentially just ordinary nodes of the network, has to find the right hash value of the puzzle, which can vary in its level of difficulty. The difficulty level states the number of leading zeros the hash value has to have, the more leading zeros the more difficult the puzzle. Participants of the network has agreed upon the fact that whoever solves the puzzle gets to create the next block. The data of the transaction combined with a number that alter the hash value of the message is required to find the hash value with the right number of leading zeros. This number is called a nonce and the correct nonce which solve the hash puzzle needs to be found via trial and error. The difficulty of the puzzle can easily be increased by adding more zeros to the hash value. This is vital for the integrity of the system since nodes seek to increase their processing power and mine more blocks as there is often a monetary reward for solving the puzzle. The decision of which transaction history to believe in is based on which chain that consists of the most blocks. Since it is computationally expensive to add a new block to the blockchain the greatest amount of work has been put into the longest chain and it is therefore considered to be the most reliable chain (Tapscott & Tapscott, 2016).

Proof of work is not the only mechanism to reach consensus in blockchains and it is often criticized due to fact that it promotes high energy usage to maintain the integrity of the system. One other mechanism is proof of stake which is mainly implemented in consortium blockchains. The mechanism lets pre-selected miners compete to solve a crypto puzzle based on a probability proportional to the stake they have put in. As the puzzle is solved miners participate in a block propagation to verify the data and thereby win a transaction fee from the user of the blockchain (Kang et al., 2019). Consortium blockchains are widely adopted and often apply proof-based consensus algorithms as for example proof-of-stake to achieve efficient consensus management. Proof-of-Stake is particularly popular as it requires low costs and power for mining (Li et al. 2017).

Other consensus mechanisms include for example *Unique node list*, which is based on social networks where new participants generates a list of other nodes they can trust in the voting on the state of affairs. However, unique node list is biased as new participants require social intelligence and reputation to participate. Another method is *Proof of activity* which combines proof of work and proof of stake and an arbitrary number of miners must use a crypto key to sign a block before it becomes official. Other methods are based on the allocation of storage for the blockchain, for example *proof of storage* and *proof of capacity* requires that miners allot portion of their hard drive to mining (Tapscott & Tapscott, 2016).

### 3.3.6 **Smart contracts**

Smart contracts assist in negotiating and defining agreements between different parties. Essentially, they are computer programs that execute settlements of agreements between organizations and people in a secure manner (Tapscott & Tapscott, 2016). The concept of smart contracts was introduced in 1994 by Nick Szabo as a way of turning contractual clauses into computer code and embedding them into property in order to minimize the need for trusted intermediaries between the transacting parties as well as reducing the risk of malicious behavior and accidents. Within the context of blockchain, smart contracts are stored on the blockchain with a unique address and allow autonomous transaction that are completely predictable. A contract is triggered by addressing a transaction to it which triggers its independent execution on all nodes of the network. In short, a blockchain supports transactions of assets between parties who do not trust each other whereas a blockchain that supports smart contracts takes it further and allows multi step processes/interactions between parties who lack trust in each other. The parties who take part in the transaction are allowed to first inspect the code and understand its outcomes. Secondly, be sure of the execution of the code since it is deployed in a network which none of the parts fully control and thirdly verify the process since all interactions are digitally signed. Thereby, the possibility of disputes is removed as the participants cannot disagree over the outcome of the transaction (Christidis and Devetsikiotis, 2016).

### 3.3.7 **Traceability and the blockchain technology**

As globalization is a major trend in society today the supply chains are getting increasingly complex with greater number of different entities spread all over the world. Reports on mismanaged supply chains with negative environmental impact, unethical labor and counterfeit products are frequently published. These types of reports have increased the demand for visibility and transparency in the supply chains. This is demanded both by intermediaries in the supply chains as well as by end consumers. To meet the demand of the end consumers several different types of certifications have been developed to prove a product's reliability. However, the consumers have no way of verifying that these certificates have been labelled correctly on a product. Providing a way of verifying a certificate demands data collection and storage on every single product in the supply chain which ought to be a tremendous task to handle for an organization. For existing certificates there is most often one central institution that issues the certificates, which requires all other entities to trust this institution. A centralized system has up until recently been the best available option but as blockchain is explored a better solution might soon exist (Abeyratne & Monfared, 2016).

It is often argued that blockchain technology can be used in a supply chain to know who is performing what actions, at what time and location. Furthermore, supply chain management may investigate the possibilities offered by DLT as the industry in general implements IoT solutions for data generation of the different activities, thus the industry generates possibilities for greater data accumulation and enables the implementation of DLT solutions for increased transparency (Kshetri 2018). Distributed Ledger Technology has inherent characteristics to address issues of inconsistent data and lack of trust and transparency among the many actors in logistics management. Issues that affect the success of international trade. DLT can help to achieve a higher level of efficiency through consistent data storage, automated workflow and tamperproof transaction history for provenance in the supply chain (Wang et al. 2018).

A blockchain solution could possibly provide a secure and immutable way of sharing records of all transactions connected to one single product that goes through the supply chain. In an article from 2016 Abeyratne & Monfared proposed what a potential application of a blockchain could look like for supply chain traceability. In their proposal a tag would be attached to each and every product, this tag functions as the connection between the physical and the digital world. As the product moves along the supply chain the tag collect information on its description, location and linked certificates. The actors of the chain; suppliers, manufacturers, retailers, standard organizations and perhaps also consumers would constitute the nodes of the blockchain and digitally sign whenever a transaction is being conducted in the supply chain. To be able to keep some information private it would be possible to change the degree of privacy depending on which entity of the chain to interact with. The rules of how to interact and share data is written in code and is then stored on the blockchain. This ensures that the rules cannot be changed, and the integrity and validity of the data is thereby secured.

### 3.3.8 Previous academic literature study

In 2018 Wang, Han and Beynon-Davies published an article where literature concerning blockchain and its application on supply chains were reviewed. The review included articles from 2008 to 2017, the terms which were used for searching nine different academic databases (*ABI Inform Global, Emerald, IEEE Xplore, JStor, Science Direct, Scopus, Springer, Taylor* and *Francis and Web of Science)* were logistics, supply chain, demand chain, value chain combined with blockchain, digital ledger, distributed ledger and shared ledger. In total 29 articles were selected to be reviewed with the aim of answering how the blockchain will influence future supply chain practices and policies. This main question was based on four research objectives:

*RO1. To identify drivers of blockchain deployment within supply chains*

*RO2. To identify areas where the blockchain provides the most value for supply chain management*

*RO3. To investigate the challenges/barriers of further diffusion of the blockchain within the supply chain*

*RO4. To develop elements of a future research agenda for the blockchain within the supply chain*

The main conclusion from the literature review of Wang, Han and Beynon-Davies (2018), ten years after the technology's breakthrough, is that blockchain still remains a novel technology with few cases of actual implementation outside the financial world. The deployments of blockchain in supply chains have mostly consisted of pilot projects but no large-scale adoption have been found. However, the reviewed literature indicated that supply chain researchers recognize the concept of blockchain and its expected value for supply chains is discussed. Some implementation strategies were even discussed in the literature, but the overall impression is that the research is at an exploratory stage. A summary of the results can be found in Table 3.2.

**Table 3.2 Summary of results by Wang, Han and Beynon-Davies (2018)**

| | |
|---|---|
| Drivers for blockchain deployment | • Trust is driving interest in BCT within SCM<br>• Need for seamless networks<br>• Reliability and security of information<br>• Product safety, authenticity and legitimacy |
| Opportunities of BCT for SCM | • Extended visibility and product traceability<br>• Supply chain digitalization and disintermediation<br>• Improved data security for information sharing<br>• Smart contracts |
| Challenges and barriers for further diffusion | • Organizational and user-related<br>• Technological<br>• Operational |
| Future research agenda | • Cryptocurrency and supply chain finance<br>• Disintermediation and reintermediation<br>• Digital trust and supply chain relationship management<br>• Blockchain, inequality and supply chain sustainability<br>• The possible "dark side" of blockchain (Ethics, security, privacy, intellectual piracy, automation-induced unemployment and technical vulnerability issues)<br>• A design perspective on a blockchain-enabled supply chain |

The blockchain pilot projects have mostly been applied in the industry of agriculture, pharmaceuticals as well as for gemstones. One example of a pilot project is a cooperation between IBM and Walmart where a blockchain-enabled tracking system decreased the amount of time to track back one package of sliced mango to its farm from 7 days to 2.2 seconds. This type of industry is thought of as suitable for blockchain since reliable traceability and product provenance not only is of importance to improve the trustworthiness of the brand but also to ensure safe products for the consumer. Diamonds are perceived as appropriate to track with blockchain since the value of one item is extremely high making the traceability crucial. The reliability, security and safety of information may be described as the trust in the supply chain. To increase the trust in the supply chain is reviewed to be the single most important incentive behind interest in blockchains. Another identified incentive is the need for seamless networks where complex and geographically dispersed supply chains easily can communicate data with each other. These types of networks also enable temporary business relationships without the need of building trust which usually is an expensive transaction cost.

Another finding in the review was that most blockchain pilot projects deployed a permissioned blockchain solution. This since plenty of the information on a supply chain are viewed as something to protect from other actors in the chain. These solutions often consist of some centralized control which determines the structure of the network.

The literature review also lists some potential challenges in implementing blockchains solutions one being that there might exist a fear of sharing sensitive information. The technology is also perceived to be very complex and thus hard to understand which increases the adoption time. Consequently, for complex supply chains an implementation of blockchain would be very costly and foremost demand great coordination between the different actors.

### 3.3.9 Common criticism of the blockchain

Blockchain has received a lot of hype and is believed to revolutionize business, companies and economies. It is often thought of as a disruptive technology, and the technology has its unique features but there are concerns, not just technical but also large-scale barriers, mainly because of the possible disintermediation. The technology rests on principles of decentralization which are different from those found in today's society, thus, there will most likely be hindrances for the adoption of the technology (Iansiti and Lakhani, 2017).

The blockchain technology offers a solution to achieve integrity in a distributed peer-to-peer system that consists of nodes with unknown reliability and trustworthiness. However, conflicting goals of the blockchain exists; more specifically the trade-off between transparency and privacy as well as the trade-off between security and speed. The foundation of the blockchain is to be open and transparent so that all transactions can be audited. The openness is in contrast to the privacy requirements of the users. The security of the blockchain is ensured by using a append-only data structure where solving a hash puzzle is required before adding a new block. This approach is time consuming and thereby limits the ability of scalability of a blockchain (Drescher, 2017).

Vranken (2017) argues that the blockchain technology has received criticism for its total energy consumption in connection with the use of its consensus mechanism proof of work. Vranken investigates the total energy consumption of bitcoin and conclude that it is in the range of 100-500 MW per year. This can be compared to the energy usage of the current banking system where, for example printing paper banknotes and minting coins are estimated to consume 1300 MW per year. In comparison with this number the consumption of a blockchain seems relatively small. However, bitcoin stands for a small part of the current financial system so the consumption will scale up if the system continues to expand (Vranken, 2017).

## 3.4 Theoretical analysis framework

The usage and acceptance of a new technology by individual users may be predicted by using the technology acceptance model developed in 1989 by Fred D. Davis. The prediction is based on two different factors; the perceived usefulness and the perceived ease of use. The perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance". The perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of effort". The actual usage of a new technology is dependent of the behavioral intention to use it which may be explained as "the extent to which a person formulates conscious plans to use or not use a technology". The behavioral intention to use is in turn related to the person's attitude towards using which is affected by the perceived usefulness and the perceived ease of use. In conclusion, the model suggests that the use of a new technology is directly or indirectly influenced by a person's behavioral intentions, attitude, perceived usefulness of the technology and the perceived ease to use the technology (Davis, 1989; Davis, Bagozzi & Warshaw, 1989).

The technology acceptance model has been modified several times since it was first developed in 1989. In technology Acceptance Model 2 (TAM2) external variables were added that explain the reasons for perceived usefulness. TAM2 stresses that the subjective norm greatly influences the perceived usefulness in which people's perceptions are affected by the social influences. The job relevance is also an important factor for the perceived usefulness which implicates the importance of matching the job goals with the consequences that may come from using the new technology (Venkatesh & Davis, 2000).

Venkatesh (2000) also added determinants of the perceived ease to use. Control is listed as important to perceive a technology as easy to use, this is explained as self-efficacy which is an individual's belief in their innate ability to achieve goals. Intrinsic motivation is another determinant which relates to the satisfaction of adapting a new behavior. Enjoyment of using the new technology is also perceived to affect the ease of use, Figure 3.5 depicts the TAM2 model and its different relations.

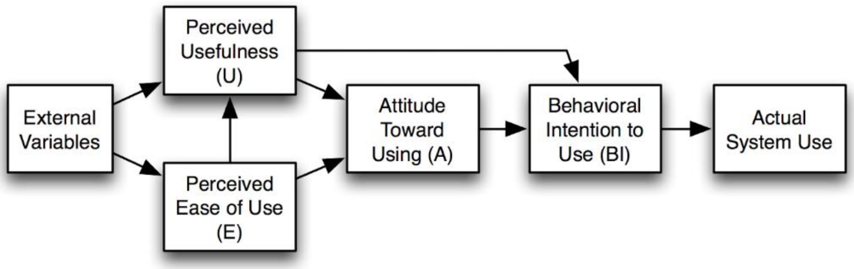


**Figure 3.5 Illustration of the Technology Acceptance Model (Davis, Bagozzi & Warshaw, 1989)**

# **4** Results

*This Chapter presents the results of the qualitative interviews conducted with different actors in the cardboard and containerboard packaging industry as well as the literature study made by the authors.*

## 4.1 Results of interview study

*As a part of the thesis the authors conducted a total of 15 different interviews, appendix B, using the interview guide found in appendix C. To be able to analyze the results the statements from the interviews were codified. In appendix E graphs display the frequency of different statements and tables present the origin of different statements. Below is figure 4.1 where the different actors who have been a part of the interview study have been mapped according to the illustration of the value chain.*

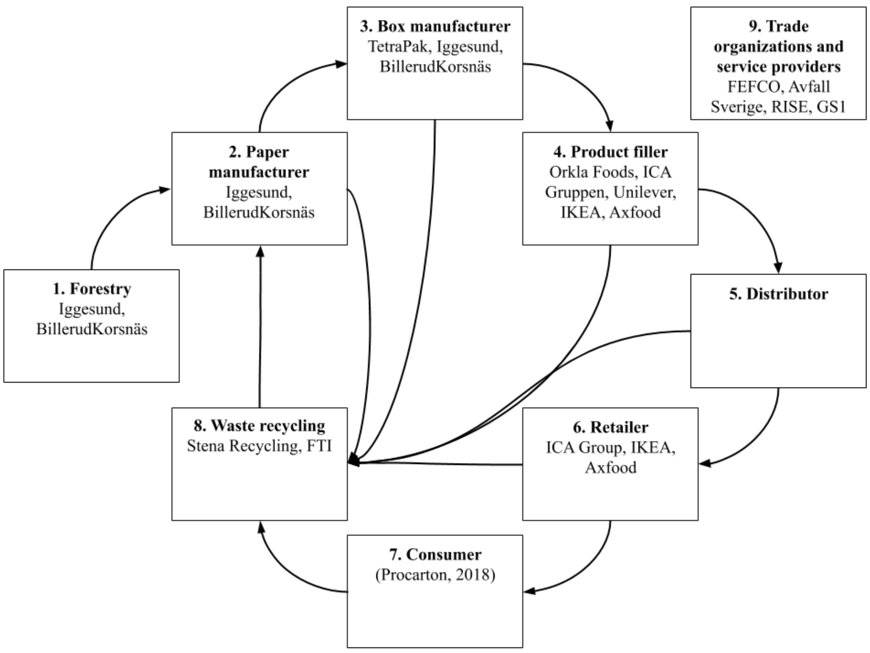


**Figure 4.1 Value chain mapped with interviewed organizations and supporting literature**

### 4.1.1 **RQ1. What are the main trends in the cardboard and containerboard packaging industry?**

#### ***4.1.1.1*** *Trends*

Below is an explanation of the trends identified by the interview study

##### 4.1.1.1.1 Circularity - increased recycling

The most frequently mentioned trend at the interview study with different actors through the value chain for cardboard and containerboard packaging is the interest of circularity and thereby increased ability to recycle or use recycled material.

According to Johan Granås, Head of sustainability at Iggesund, the climate aspects have become more important for the customers of Iggesund and they seek ways to reduce the carbon footprint of their business. According to Granås, these trends result in an increased interest in recycled fibers which is not a part of Iggesund's offering as they only sell products based on virgin wood fibers, the reason being that Iggesund only focus on exclusive products of high quality. Granås emphasized the need to make data driven decision when deciding what materials to use for packaging, especially in terms of sustainability, as the process of making paper from either virgin or recycled fiber requires large amounts of energy. Thus, the energy source for the paper mill have a large impact on the total carbon footprint of the packaging (Granås, 2019 1st of March, Interview).

Furthermore, the interviews showed that product fillers (brand owners) mainly focused on the ease to recycle material used in their packaging. Sofia Erixson, Packaging developer, at Orkla Foods explained that the development of packaging has become increasingly important and that Orkla Foods put a lot of effort into making more efficient packing that helps to reduce the food waste. This since the main contribution to their climate impacts comes from the product protected by the packaging. Erixson explained that in general 90% of emissions comes from the production of the actual product and thus it is of uttermost importance that the packaging ensures the safety of the product and minimizes the waste. Consequently, Erixson explained that the main focus within Orkla Foods' packaging development is to make recycling easier as well as ensure the food safety. Since Orkla Foods sells food products they are exposed to extensive legislation on what materials are allowed to be in contact with food, for example, recycled fibers are not allowed to be in direct contact with food. Thus, they try to make sure that the packaging material can easily be recycled to increase the sustainability of their business (Erixson, 2019 14th of March, Interview).

Diana Seleznova, Sustainability developer at IKEA, also focused on the climate agenda, packaging optimization as well as circularity as some of the main trends for packaging. The carbon footprint of cardboard and containerboard packaging is also of great interest for IKEA as they see it as one of the most important parameters upon choosing what packaging material to source, but of course the cost is also an important parameter. Diana explained that they have found a way to promote circularity that also is cost efficient and solves sourcing problems. As some markets lack the possibility to locally source cardboard and containerboard packaging material IKEA has introduced ways to ensure that they can re-use material of their own products (Seleznova, 2019 21st of March, Interview).

Einar Ahlström, material specialist at FTI, explained that the most prominent trend to his experience is the focus to make packaging materials easier to recycle. FTI has extensive contact with product fillers and try to collaborate to make recycling more favorable (Ahlström, 2019 6th of March, Interview).

Per Funkquist, Business Developer Forest Certification at BillerudKorsnäs, also agrees that there is a large focus on circularity but is mildly critical to legislation introduced by the European Commission as the target levels of recycled material is much lower for plastics compared to paper based products and thus premiers plastics. BillerudKorsnäs expected that the packaging directive would promote paper-based products that, according to Funkquist, is better based on a LCA compared to plastics but the directive focuses more on the actual recycling than the environmental impact (Funkquist, 2019 21st of March, Interview).

##### 4.1.1.1.2 Increased demand and value of cardboard and containerboard packaging material

Krassimira Kazashka, Technical director at Fefco, explained that the expanding business of e-commerce is expected to result in an increased use of especially corrugated board packaging. Corrugated board is a type of board that consists of a high degree of recycled fibers making the circular economy a reality. Additionally, the packaging is no longer seen only as a protecting layer but also a part of the offering and thus becomes more valuable (Kazashka, 2019 6th of March, Interview).

IKEA is constantly increasing their usage of packaging material and especially cardboard and containerboard, as explained previously, the material is essential for the business and on markets where there is no sufficient local supply IKEA has set up circular models to support their sourcing (Seleznova, 2019 21st of March, Interview).

BillerudKorsnäs also perceives that there is an increased demand and use of paper packaging, this is because increased urbanization globally drives the use of packaging as consumer purchase goods in stores rather than on markets. As the climate perspective is becoming increasingly important bio-produced paper is interesting for BillerudKorsnäs customers (Funkquist, 2019 21st of March, Interview).

##### 4.1.1.1.3 Reduced use of plastics

Another trend mentioned frequently is the wish to avoid using plastics and to find new alternative materials. This was especially expressed by actors early in the lifecycle, the forestry and paper manufacturer as well as by those at the end of the cycle, the waste recyclers. Johan Granås, Head of sustainability at Iggesund Paperboard, explained that one megatrend right now that affect their business is the focus on plastics polluting the oceans. This results in an increased demand of packaging based on renewable material (Granås, 2019 1st of March, Interview).

Ann Lorentzon at RISE and Normpack (who help organizations with requirements of safer materials in contact with food) also see that the legislation on plastics affects the industry and results in the introduction of completely new materials. Materials which there are little knowledge of as well as no existing legislation for, this introduces new challenges (Lorentzon, 2019 18th of March, Interview).

4.1.1.1.4 Demand of transparency

Recycling fibers is not straightforward and does add to the complexity of production, as for example, it is challenging with an inflow of material of varying quality and sorting is needed. Jon Djerf at Avfall Sverige explained that there is a need for increased traceability of the origin of the product as well as its composition. This is because recycled material can generate toxins, and since brand owners seek to make more sustainable product choices, the possible introduction of toxins is alarming (Djerf, 2019 7th of March, Interview).

According to Sandra Pousette, Senior project manager at RISE, consumers demand increased transparency mainly to ensure they do not purchase counterfeit products and she believes the packaging itself could play a vital role in ensuring the authenticity of the goods (Pousette, 2019 19th of March, Interview).

Martin Hörberg, Head of packaging and traceability at ICA group, emphasized that increased transparency throughout the whole value chain is of great importance as a strategy to defend one's brand and avoid scandals. He believes that future traceability will be greatly influenced by customer and legal requirements (Hörberg, 2019 19th of March, Interview).

Johan Granås also drew attention to increased transparency as a way that Iggesund will increase competitiveness and that they wish to increase traceability through the value chain (Granås, 2019 1st of March, Interview). Jon Djerf at Avfall Sverige also experience a need for increased traceability as it is interesting to them to know the actual composition of the object that is to be recycled (Djerf, 2019 7th of March, Interview).

### 4.1.2 RQ2. What traceability exists in the value chain of cardboard and containerboard packaging and how does the different actors perceive existing traceability?

#### ***4.1.2.1*** *Traceability available today*

Below is an explanation of the existing traceability identified by the interview study

##### 4.1.2.1.1 Batch information

Traceability through, at least some parts, of the value chain for cardboard and containerboard packaging is not anything new. But different actors within the chain do track different things and in different ways. Actors like Iggesund and BillerudKorsnäs does, due to their FSC certification, keep records of incoming batches of wood in different forms and can thus perform tracing of the origin of the material. What is problematic though is that due to the process of producing paper the traceability is lost and the actual origin for batches of rolls of paper becomes "impossible" as wood fibers mix (Granås, 2019 1st of March, Interview). Per Funkquist at BillerudKorsnäs explains that one could guess where a batch of paper originates from as they have deep knowledge of their production but that would only be a sort of educated guess based on possible mass balance (Funkquist, 2019 21st of March, Interview).

Actors like Tetra Pak that make carton and containerboard packaging out of the paper provided by for example BillerudKorsnäs does also keep track of what material enters their production process. Since the packaging material that is manufactured by Tetra Pak factories is in direct contact with food there has to be a possibility to track material throughout the value chain. For example, each roll of paper from suppliers has an individual barcode so that it is possible to log production events to that specific batch of paper if any defect were to show up. All paper suppliers to Tetra Pak are FSC certified (Fox, 2019 5th of March, Interview).

Martin Hörberg at ICA Group explained that they use dynamic variable data and GS1 master data to create their traceability and that the traceability they have today mainly concerns the actual product and not the packaging and its composition. He emphasized that there is a need for a standardized way to format data and that ICA Group is actively taking part in work together with GS1 to create standards for describing objects. He believes that the traceability data can create great customer value but the formulation of standards are the main priority at the moment, before one can move forward and explore how it should be packaged, accessed and for what types of products and customer groups it is of interest to show the traceability data (Hörberg, 2019 19th of March, Interview). Karolin Catela at GS1 explained that the GS1 Standards allow tracking of individual products by identifying and capturing the information in a two-dimensional barcode. A new standard called GS1 Digital Link enables access for business-to-business and business-to-consumer information stored on the web. This enables brand owners to reach individual customers (Catela, 2019 19th of March, Interview).

#### 4.1.2.1.2 Manual labor

The sort of traceability that exists within foods is mainly based upon contracts and trust. Zsófia Réger at Axfood explained that due to a lack of resources and systems to follow up information given by their suppliers they mainly trust that suppliers keep their policies and asks for certificates (Réger, 2019 3rd of April, E-mail).

Sofia stated that Orkla Foods calculate the environmental impact of the packaging by asking their suppliers for emission data who then turn to their suppliers and so on. This data then ends up in a Excel Spreadsheet to help understand the carbon footprint of Orkla's business (Erixson, 2019 14th of March, Interview).

Ann Lorentzon, Project Manager in product safety at RISE and leader of Normpack, an industry group that works for safe materials in contact with food, explained that today's traceability of safety aspects builds on a chain of declarations of compliance (DoC). For example, a material manufacturer is the most knowledgeable actor as of the composition of a given material, thus they issue a DoC. A packaging manufacturer must consequently collect DoCs from all different manufacturers of materials; paper, metals, plastics etc. for a given product and issue an own DoC based on these documents. For plastics there exists clear frameworks for the content of the DOCs but for other materials there are no given methods, and it happens that the DOCs are not correct, consequently it is essential to work close with serious suppliers. To create traceability through the value chain manual labour is required as one must review all given DoCs (Lorentzon, 2019 18th of March, Interview).

Diana Seleznova at IKEA described that IKEA has certain technicians who randomly visits suppliers of packaging material as a way to check if they follow their practices. Additionally, she explained that it is relatively easy to switch packaging suppliers compared to for example furniture suppliers. The reasons for switching packaging suppliers are not always because of financial reasons but rather related to compliance, business contingency and risk mitigation (Seleznova, 2019 21st of March, Interview).

#### 4.1.2.1.3 Traceability must exist for food and medicine

In some industries there must exist some sort of traceability to ensure product safety, this is especially within food and pharmaceuticals. If there is no traceability or knowledge of the value chain one cannot be sure of fulfilling the legal demands for food for example (Lorentzon, 2019 18th of March, Interview).

Sofia Erixson at Orkla Foods stated that since they only work with packaging that is in contact with foods, they know to what extent recycled fibers occur in their packaging. Furthermore, Orkla Foods have information of products on a batch-level which helps in case breached food safety and product recalls are necessary (Erixson, 2019 14th of March, Interview).

#### ***4.1.2.2*** *Level of trust in the value chain*

The general opinion in the industry is that trust exists between the different actors. However, the foundation of trust is described in different ways. Below are the most common foundations of trust defined and exemplified.

##### 4.1.2.2.1 Close partnerships in the industry

Several of the interviewees pointed out that the business builds on close relationships which favor the trust. Krassimira Kazashka, Technical Director at Fefco, stated that the paper & board industry works closely together and rely on each other for the information provided in the supply chain. This is probably one of the reasons why she never has come across any type of misuse of data (Kazashka, 2019 6th of March, Interview). This view is to a great extent shared by product fillers in the industry. Both interviewees from Unilever and Axfood described that they have agreements with their suppliers which they fully trust are fulfilled (Réger, 2019 3rd of April, E-mail; Lönegård, 2019 29th of March, E-mail).

Even though the general opinion clearly states that trust exists in the industry Martin Hörberg at ICA group and Sofia Erixson at Orkla Foods explained that blind trust cannot be placed on the suppliers. However, both agreed that building long-lasting relationships increases the trust (Hörberg, 2019 19th of March, Interview; Erixson, 2019 14th of March, Interview).

The importance of close partnerships is also stressed at IKEA where nominated packaging suppliers are used whose role is to supply the nearby producers of goods. These suppliers must follow certain predetermined parameters when it comes to price, quality, supply and sustainability. This system is perceived as reliable but cannot be trusted to 100 % which is why continuous onsite check-ups are conducted at the suppliers (Seleznova, 2019 21st of March, Interview).

##### 4.1.2.2.2 Reliable certification

The use of FSC-certification is widespread and the actors in the value chain place trust in the certification which helps build trust between the actors. At BillerudKorsnäs the FSC-certification is seen as an important tool to build trust with their suppliers. Per Funkquist stressed that all FSC-certified suppliers are trustworthy since the certification itself is trustworthy (Funkquist, 2019 21st of March, Interview).

Iggesund is another company that is FSC-certified and Johan Granås described this certification as one way of building trust but at the same time stresses the importance of welcoming their customers to come visit their production site. This way the customers get an insight in the production which Johan Granås perceived to be an effective way of reaching trust (Granås, 2019 1st of March, Interview). Additionally, Krassimira Kazashka at Fefco stated that the markets are requiring certificates and for the companies they are an important tool to build trust with customers and consumers (Kazashka, 2019 6th of March, Interview).

4.1.2.2.3 Product that impedes cheating

A third foundation of trust is that the characteristics of a package makes it very hard to cheat. Martin Palmér at Stena Recycling explained that the amount of recycled fiber does affect the quality of a product since the strength is reduced as it is recycled. This means that a product with more virgin fibers will have greater strength per grammage, its mass per unit area. Consequently, a box of recycled fibers, in general, must be thicker to compensate for the weaker fiber. Moreover, the quality of the paper or board does affect its processability, therefore, a paper that does not live up to the promised properties risk to interrupt the production process and cause costly outages (Palmér, 2019 4th of March, Interview). Jon Djerf at Avfall Sverige addressed the same topic by explaining that the production and the quality are too sensitive to be able to cheat (Djerf, 2019 7th of March, Interview).

***4.1.2.3*** *Incentives for increased traceability*

Krassimira Kazashka at Fefco finds traceability systems today as sufficient for the current needs but assert that it is time-consuming to set them up. Furthermore, she explains that the trends of industry 4.0 could increase the speed of traceability and the amount of data available (Kazashka, 2019 6th of March, Interview).

Most of the interviewees agree upon the fact that there exist incentives for increased traceability in the cardboard and containerboard industry. However, there is a difference of opinion on what the incentives are and above all how the traceability may be improved. Four of the interviewed actors state that all relevant information already is available in the traceability system, it is just a question of how to share the information in a trustworthy and efficient way. Karolin Catela at GS1 explained that the focus of GS1 is supporting actors in the industry to work in a standardized way of sharing traceability data (Catela, 2019 19th of March, Interview).

Martin Hörberg at ICA group shared the opinion of that the information is available but that it has to be communicated in a global standardized way (Hörberg, 2019 19th of March, Interview). Other actors like Orkla Foods are focusing on how the traceability may be increased by adding more data to the system, in specific, data of every individual package (Erixson, 2019 14th of March, Interview).

At Tetra Pak the possibility of individual package traceability is explored as well, mainly to offer this feature for the customers who fill the packages to support their marketing (Fox, 2019 5th of March, Interview). When it comes to the incentives behind the wish for increased traceability the following main topics have been identified.

4.1.2.3.1 Transparency

The incentives for increased traceability are to a great extent linked to the desire of being as transparent as possible, mainly because of the requests from customers and consumers who are demanding more sustainable packages. Customers want to be able to know where a package end up being used, something that could possibly be enabled by individual barcodes (Fox, 2019 5th of March, Interview). Martin Hörberg agreed and stated that the most important incentive for traceability in the future will be increased demands from customers as well as legislation (Hörberg, 2019 19th of March, Interview).

#### 4.1.2.3.2 Legislation

Legislation is the second most mentioned incentive behind increased need for traceability. Both Ann Lorentzon and Sandra Pousette at RISE stressed that the legislative factor is the most seminal one when it comes to initiatives for increased traceability (Lorentzon, 2019 18th of March, Interview; Pousette, 2019 19th of March, Interview). Martin Palmér at Stena Recycling also underlined the importance of legislation and states that prevalent legislation ensures that a enough degree of traceability is in place (Palmér, 2019 4th of March, Interview). On the other hand, working proactively with increasing traceability may be strategically beneficial since new potential legislation may demand more robust traceability systems to be implemented (Ahlström, 2019 6th of March, Interview).

#### 4.1.2.3.3 Efficient supply chains

A third common incentive is the wish for a more efficient supply chain. Karolin Catela at GS1 mentioned that finding more standardized way of tracking products is perceived to contribute to a more fast-moving supply chain (Catela, 2019 19th of March, Interview). More specifically, the ability to track products in a faster manner is desirable. As of today, there is a labor-intensive procedure in place for tracking and tracing in case of any failure of a supply chain. A less time consuming and more reliable solution would be preferred (Fox, 2019 5th of March, Interview).

Zsófia Réger at Axfood also elaborated on the desire of a system where actors log events and where information about the packages easily can be retrieved (Réger, 2019 3rd of April, E-mail). Diana Seleznova at IKEA perceived that the major incentive is controlled supply of the raw material and the ability to predict if there will be a business disruption and secure availability. Furthermore, Seleznova believed that increased traceability could facilitate the comparisons between different manufacturers and thus the selection process would be faster and more reliable (Seleznova, 2019 21st of March, Interview).

#### 4.1.2.3.4 Facilitate use of sustainable metrics

Increased traceability also has the potential to facilitate the measuring of the supply chain efficiency when it comes to sustainability metrics. As of now it is most often difficult to get data from suppliers on their carbon footprint and in the cases where the data is available it is hard to process it manually (Seleznova, 2019 21st of March, Interview). To be able to communicate the carbon footprint would not only be beneficial when selecting suppliers but also to prove a brands sustainable advantages to the customers (Granås, 2019 1st of March, Interview).

#### 4.1.2.3.5 Strengthen the reputation of the brand

Martin Hörberg also emphasized that increased traceability has the possibility to decrease the amount of scandals in a value chain which in turn would have a positive effect on retaining a value of a brand (Hörberg, 2019 19th of March, Interview). Johan Granås at Iggesund also elaborated on possible impacts on a brand's reputation and explained that their vision at Iggesund, is to be as transparent as possible for the sake of their customers. Furthermore, he described that the greatest benefit of increased traceability would be the ability to easily communicate their products advantages and thereby improve the reputation of the brand (Granås, 2019 1st of March, Interview).

### 4.1.3 RQ3. Are there any existing blockchain initiatives within the cardboard and containerboard packaging industry?

#### ***4.1.3.1*** *Blockchain initiatives and general opinions*

Out of the 15 interviewed people only four were aware of blockchains projects in their respective companies. The other eleven interviewees were aware of the technology, or had at least heard of it, but no efforts within the field had been done or even discussed in their organizations to the knowledge of the interviewees. In general, very few knew more about the technology than that it is used for bitcoin.

A company that has started to explore the blockchain technology is Unilever, they are currently running a trial in the accounts payable process of the American supply chain. A blockchain implementation could facilitate the process of making sure that invoices are approved, processed and paid without manual intervention (Unilever, 2019a).

At Tetra Pak a front-end innovation group has been investigating the possibilities of blockchain. The company has embraced the blockchain platform developed by IBM which is called TradeLens where shipping events on the supply chain are logged (Fox, 2019 5th of March, Interview).

In 2017, Axfood conducted a study to identify how blockchain may help improve the traceability and transparency of food. This resulted in two identified use cases where blockchain may contribute to increased transparency; ensure sustainable conditions at the production facility and traceability of volumes and items along the supply chain “from land to table”. Currently, test pilots on these use cases are running (Kairos Future, 2017).

GS1 has explored blockchain as it could be a suitable technology to share information between trading partners. However, as GS1 focuses on standards for identifying items, places and parties, they do not make any judgements of new technologies and their feasibility, they just provide useful insights on what type of technology that is appropriate for storing different types of data (Catela, 2019 19th of March, Interview).

## 4.2 Results of Literature review

*Based on the literature review of 19 academic peer-reviewed articles published between January 2018 and January 2019 the following main drivers, opportunities and threats were identified for the blockchain technology in a supply chain context. Below it is presented how frequent the identified drivers, opportunities or threats are mentioned in the literature of this study. Only terms and concepts that were mentioned in two or more different articles were included in the compilation of data. The authors have chosen to include explanations of the drivers, opportunities and challenges, presented in tables, and elaborate more thoroughly and exemplify the top three elements of each category to ease the reading. The list of the 19 articles can be found in appendix D.*

### 4.2.1 **RQ4. What are the drivers, challenges and threats of implementing blockchain solutions in supply chains?**

#### ***4.2.1.1*** *Main drivers for blockchain technology*

Below the main reasons for exploring blockchain technology in supply chains are presented. First, there is an explanation of the different drivers, see Table 4.1, followed by a presentation of the ones occurring in the literature the most often, see Figure 4.2.

**Table 4.1 Identified main drivers for blockchain implementation in supply chains**

| **Driver** | **Explanation** |
|---|---|
| *Lack of trust* | Intermediaries in supply chains does not seem to trust each other fully |
| *SC optimization* | Increased integration of ICT-systems between different actors to enable new functionalities and services |
| *Transparency for customers* | Customers and consumers want to know the origin of a product, shipping status and environmental impact of the supply chain |
| *Consistent data* | Actors want logical and ordered data |
| *Cost reduction* | Increased data/knowledge of the supply chain is believed to help actors make better decisions and cut costs |
| *Increased sustainability* | Actors seek to reduce waste, certify environmentally friendly options and support new business models |
| *Risk reduction* | The ability to track goods quickly can help reduce risk, for example if batches of food are contaminated a brand owner wants to act quickly to reduce the potential damage of the brand |

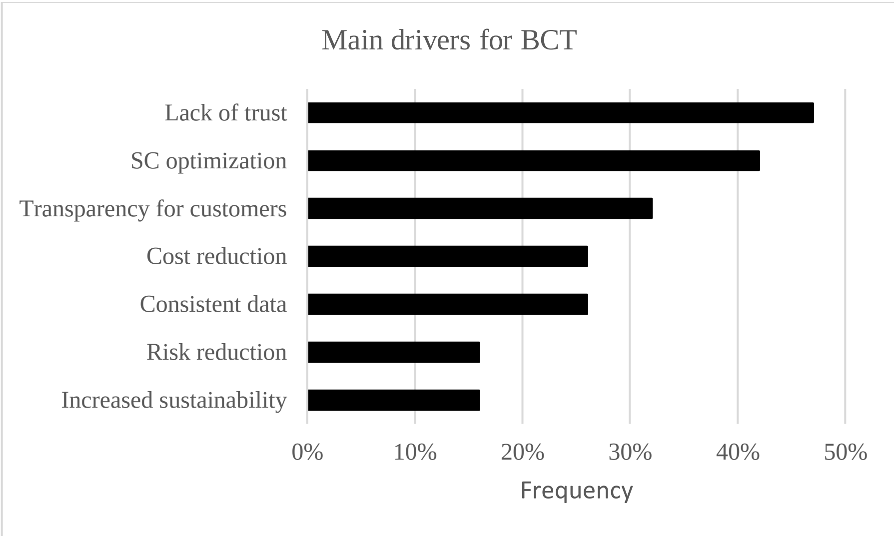


**Figure 4.2 Identified main drivers for blockchain implementation in supply chains and how often they are found in literature**

According to the study the main driver for exploring blockchain applications in supply chains is the *lack of trust* between intermediaries of the supply chain. For example, Wang et al. (2018) argues that current solutions for logistics management are prone to inconsistent data, lack of trust and transparency between the different actors of the supply chain and that BCT is focused on addressing these sorts of challenges. Kshetri (2018) claims that an important part of gaining trust of all the involved parties of a supply chain is to be able to audit all transactions made, which is a possible feature of a blockchain solution. The lack of trust and transparency is not just seen as a major area of improvement between the different value-adding actors of the supply chain, growing numbers of consumers also demand transparency.

A main driver for investigating BCT is the possibility to *optimize the supply chain*. For example, Gao et al. (2018) argues that the supply chain naturally is a multiparty distributed system and that most companies and stakeholders today use their own SCM systems which struggle with integration and that end-to-end tracking enabled by BCT will enable new functionalities and services. Complex supply chains also demand advanced form of communication and data exchange which may not be suitable to manage in a centralized manner, making a distributed system like blockchain technology more appropriate (Andoni et al. 2019).

Typical supply chains that are exposed to an increased demand for *transparency of consumers* are ones dealing with agricultural goods and food. Several incidents have been reported where fake organic products or contaminated meat have been sold on the market (Li and Wang, 2018). Improved transparency of these supply chains opens for possible premium pricing models as consumers seek food that is safe and of high quality (Caro et al. 2018). Apart from buying safe food consumers also focus on making environmental-friendly purchasing decisions. According to Kouhizadeh and Sarkis (2018) green marketing theory states that consumers are more likely to buy green products if evidence of its provenance exists. This can be accomplished by storing that kind of information on a blockchain.

#### ***4.2.1.2*** *Main opportunities with blockchain technology*

Below we present and explain the primary opportunities identified by recent literature. First, there is an explanation of the different opportunities, see Table 4.2, followed by a presentation of the ones occurring in the literature the most often, see Figure 4.3.

**Table 4.2 Identified main opportunities with blockchain implementation in supply chains**

| **Opportunity** | **Explanation** |
|---|---|
| *Reduced transaction costs* | A decentralized system will reduce the need for involvement of a third party and thus reduce costs |
| *Transparency* | Blockchain is an open ledger, at least to those participating in the chain, and it will promote transparency |
| *Reduce ability to cheat* | With transparent and consistent data stored on blockchains the ability to cheat is believed to be reduced |
| *Reduced need for central authorities* | Applications proposed in articles often reduce the need for central authorities as actors are linked to each other with the help of the blockchain |
| *Facilitate documentation* | Storing data of the supply chain on the blockchain will help to ease documentation |
| *Tamperproof data* | The properties of blockchain is believed to create tamperproof data which can be of great use in SCM |
| *Asset tracking* | Increased ability to track goods in the supply chain and determine the location |
| *Ease of new business relationships* | Smart contracts, supported by BCT, is suggested to make it easier to create new and short-term business relationships, with for example shippers or suppliers. |
| *Increased efficiency* | The amount of available data is supposed to help increase the efficiency of the supply chain |
| *Ensure provenance* | The technology is suggested to help verify the origin of a good |
| *Facilitate audits* | Blockchain can help to support certification steps of supply chains |
| *Waste reduction* | The increased amount of information and new business models is believed to decrease spill |

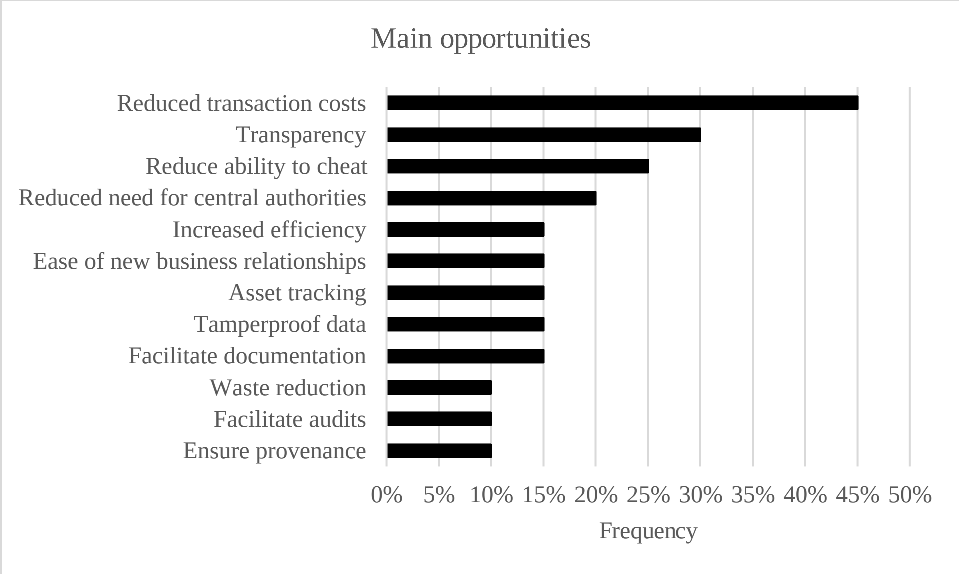


**Figure 4.3 Identified main opportunities with blockchain implementation in supply chains and how often they are found in literature**

The main opportunity with blockchain technology in supply chains according to the articles of this study is what often is described as the main feature of cryptocurrencies, *reducing the cost of transactions*. It is argued that BCT will requires less support from the banking sector and thus decrease the costs of transactions(Gausdal, Czachorowski and Solesvik, 2018), eliminate the need for third party involvement (Min, 2019) and reduce costs of auditing and monitoring activities since BCT will reduce inappropriate and opportunistic behavior (Saberi et al. 2018).

*Transparency* is another opportunity often promoted, for example, Min (2019) explains that visibility across the supply chain will increase as a result of the open ledgers and therefore increase the transparency. Treiblmaier (2018) argues that the increased transparency as resulted from the implementation of BCT will help reduce fraud and errors.

To *reduce the ability to cheat* is perceived to be the third most valued feature of the blockchain. Kshetri (2018) does for example mention that an implementation of blockchain may have significant social impacts. It would for example benefit the coffee supply chain which is described as an industry without proper techniques of monitoring the involved actors and their work for social sustainability.

#### ***4.2.1.3*** *Main challenges for blockchain technology*

Below is a presentation and explanation the primary challenges for blockchain implementation identified by recent literature. First, there is an explanation of the different challenges, see Table 4.3, followed by a presentation of the ones occurring in the literature the most often, see Figure 4.4.

**Table 4.3 Identified main challenges for blockchain implementation in supply chains**

| **Challenge** | **Explanation** |
|---|---|
| *Limited scalability* | The security measure of a shared ledger comes at the price of reduced processing speed and hence limited scalability |
| *High implementation cost* | The implementation of blockchain demands new IT-systems and likely new organizational structures which is estimated to be expensive |
| *Lack of common standard* | No existing standard on how to implement a blockchain which may lead to one blockchain for every single supply chain |
| *Organizational change* | Need of changing current organizational structures which may lead to resistance among the personnel |
| *Lack of BCT understanding* | People do not understand the technology and its opportunities |
| *Lack of proof of concept* | Majority of blockchain frameworks have not been implemented and thus lack a proof of concept |
| *Can technology be trusted* | Is the technology developed thoroughly enough to be trustworthy, often linked with lack of understanding |
| *Lack of expert knowledge* | Few existing blockchain experts to educate people on the topic |
| *Permissioned blockchain similar to centralized database* | The distribution of power is characteristic for the blockchain. When creating permissioned blockchains this characteristic is changed and the database thereby has many similarities to an ordinary centralized database |
| *Security* | Is the asymmetric cryptography secure enough? If a private key is lost the security model in a blockchain fails |

| | |
|---|---|
| *Energy intensive* | Solving a hash puzzle demands great amount of computing power and thereby energy |
| *Interface between digital and physical domains* | The difficulty of finding an appropriate interface to connect a physical attribute to a solely digital system |
| *Lack of management commitment* | Decision makers within industries are not committed to implementing the new blockchain technology |
| *Lack of governmental policies* | Legal implications of transactions managed by the blockchain is yet to be discussed |
| *Coordination* | The implementation of blockchain will demand high level of coordination between the different entities in the supply chain |

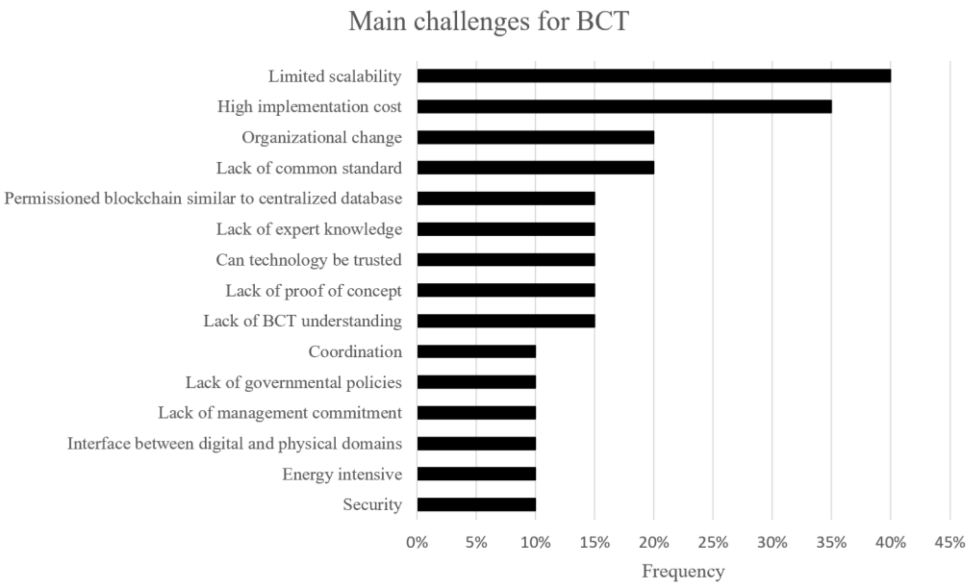


**Figure 4.7 Identified main threats for blockchain implementation in supply chains and how often they are found in literature**

The main concern with the implementation of blockchains is the possible scalability of the systems. Tribis, El Bouchti and Bouayad (2018) argues that the majority of the proposed frameworks based on blockchain only have been tested on a limited scale in a laboratory environment and that challenges might arise as the number of nodes increase. An additional *scalability problem* is the fact that a blockchain would require a great amount of computing power to manage large quantities of data (Radanović and Likić, 2018). Furthermore, the time-consuming mining process in a blockchain leads to a limited throughput when adding new blocks to the chain

(Gao et al. 2018). Min (2019) agrees on the problems with scalability but also explains that limited financial resources and lack of technical structure and knowledge might hinder the adoption. Financial resources needed when implementing a blockchain solution may be divided into different categories. There are *implementation costs* when configuring the new system with existing ones as well as costs for the actual platform to be used. Apart from this, cost of training the operators will be added as well as maintenance costs (Perboli, Musso and Rosano, 2018). The fact that the technology is in its early stages of development is also believed to limit the scalability (Saberi et al. 2018).

The human side of the implementation and the organizational change is often mentioned as a threat to the technology, for example a standard is needed for a supply chain which requires all relevant parties to meet and adapt their systems (Tribis, El Bouchti and Bouayad, 2018). Wüst and Gervais (2018) reason in a similar way and argues that the roles of participants can vary greatly in different supply chains and warns for the *lack of common standards* and the risk that blockchain must be developed for every single supply chain. Adopting the technology in supply chain processes is believed to require new roles, responsibilities and expertise and thus not only challenge the organizational structure but also drive costs (Saberi et al. 2018).

# 5 Discussion

*This Chapter presents a discussion of the findings of the studies and their relation to the research questions. The findings are applied to the technology acceptance model to structure the discussion and better understand the perceived usefulness and usage intentions. Firstly, the perceived usefulness of the blockchain is discussed and secondly its ease of use is discussed. Next is an elaboration of the contributions of the thesis as well as its possible limitations.*

## 5.1 Usefulness

To evaluate if blockchain may be perceived as useful to implement in the cardboard and containerboard packaging industry a comparison of the literature study and the interview study was made. The drivers for increased traceability, found in the interview study were compared to the drivers of implementing blockchain in supply chains found in the literature study. To further analyze whether blockchain may be perceived as useful to implement, the product specific features of cardboard and containerboard were compared with products from industries where blockchain solutions have been considered appropriate according to the literature study. Lastly, it was analyzed how blockchain can be useful to improve the traceability of recycled fibers and if it may be viable for alternative types of applications in the cardboard and containerboard packaging industry.

### 5.1.1 **Comparison of literature study and interview study**

The comparison of the literature study and the interview study, which can be seen in Table 5.1, showed that two out of three identified main drivers of improved traceability in the cardboard and containerboard packaging industry can be found as drivers for implementing blockchain in general supply chains as well. The greatest incentive for increased traceability was the possibility to provide transparency for the customers. In the paper published by Procarton in 2018 it was evident that consumers of cardboard and containerboard packaging wished for increased guidance on how to make sustainable purchasing decisions. The actors in the value chain of cardboard and containerboard packaging also perceive it as important to be able to communicate the origin of the components of their products. Some of the interviewed actors stated that all relevant information already is available, and some expressed a wish for some added parameters of information, but they all shared the opinion that there is a challenge in how to share the information in a trustworthy and efficient way. In the literature study it was found that increased transparency for customers was the third mostly mentioned driver for implementing blockchain solutions. As identified in the literature, one of the greatest opportunities of a blockchain is that it is an open ledger, at least to those participating in the chain, and thereby it will promote transparency.

Another important incentive for increased traceability found by the interview study was to optimize the supply chain. More specifically, the ability to track items in a faster manner in case of failures on the supply chain was described as desirable. This aligns with the literature study, where increased integration of ICT-systems between different actors is the second most important driver for using the blockchain technology to enable new functionalities and services. Blockchain is believed to promise plenty of opportunities for increased integration of ICT as it could facilitate the documentation, increase the ability to track goods in the supply chain and determine the location of products. Furthermore, it is believed that the increased amount of information available thanks to a blockchain implementation can result in optimized processes and reduced waste.

Increased trust was, in the literature study, identified as the most significant driver for implementing blockchain. The interview study did not identify this driver in the cardboard and containerboard packaging industry where the trust is described to be widespread among the different actors. Instead legislation is among the top three incentives for increased traceability. It can be argued that the extensive legislation for packaging material is a foundation that helps to build trust in the industry, as there are external parties forcing the actors to follow a predetermined set of laws. However, in the qualitative studies it was explained that the trust to a great extent is built upon long-lasting relationships between customers and suppliers.

Even though a blockchain implementation may entail supply chain optimization and increase transparency it is not seen as a useful solution today since the industry is based on trust between actors. It is often emphasized that there must be a combination of drivers, especially concerning trust, for blockchain to offer a competitive solution to a given business case and legitimize the needed efforts and investments for development of the technology. Consequently, other types of less complex databases may be implemented to improve traceability in an easier and more cost-effective way.

**Table 5.1 Comparison between drivers from the two literature studies**

| Drivers for blockchain deployment found in the literature study from 2019 by Ragnarsson and Trulsson | Drivers for increased traceability in the cardboard and containerboard industry found in the interview study from 2019 |
|---|---|
| • Lack of trust<br>• Supply chain optimization<br>• Transparency for customers | • Transparency for customers<br>• Legislation<br>• Supply chain optimization |

### 5.1.2 Product specific features

According to the conducted literature study appropriate industries for a blockchain implementation would be ones where product provenance not only is of importance to improve the trustworthiness of the brand but also to ensure safe products for the consumer. It is also argued that the technology is suitable if the products are perceived to be of high value. These assertions are contrary to the characteristics of a package made from cardboard or containerboard.

The value of the content in a package may be of high value but the actual package cannot be perceived as a high value-product even though the increased interest in renewable material in some way increases the interest in the packaging. Furthermore, the quality of a wood fiber is greatly affected by recycling which makes it relatively easy to determine whether a package contains recycled fibers or not which in turn makes it hard to cheat when it comes to the ingoing components of a packaging. Still, it is not possible to determine to what extent the packaging contains recycled material. But as discussed later in this paper, this might not be the most interesting aspect to verify in the mission to become more sustainable.

The product provenance of a packaging is of importance depending on its content. When packing food or pharmaceuticals the provenance of the packaging is important due to safety reasons. However, these industries are exposed to extensive legislation which is seen as the foundation for trust. To summarize; a cardboard package is of low value, its characteristics makes it hard to cheat with ingoing components and to ensure provenance is important when packing food or pharmaceuticals.

The characteristics of a package does not have many similarities with products for which blockchain solutions have been thought of as useful before. The low monetary value of a cardboard or containerboard packaging and the fact that its characteristics makes it hard to cheat with ingoing components does not speak in favor of a blockchain solution.

### 5.1.3 Possible fields of application for BCT

The purpose of this thesis was to explore whether blockchain technology can be used to determine the distribution of recycled fibers versus virgin fibers in a cardboard or containerboard packaging. However, there is an enormous amount of fibers in one package which would make it physically and financially unfeasible to track the origin of every single fiber today. For financial and technological reasons and the complexity of linking a physical fungible good with a digital asset it was instead explored whether a transaction based blockchain could be useful. A solution where all incoming transactions of wood or recycled packaging are stored on a blockchain.

The transaction information could enable actors to compare the incoming fibers with the outgoing goods and thereby know the overall mass balance of recycled fibers versus virgin fibers currently in the value chain. However, a mass balance system is currently used by the FSC-certification and since the industry place great trust on the certification there is no need to transfer the same type of system to a more complex technology like blockchain today. The technology may have potential to influence the certification process in the future depending on the development of the organization behind FSC. The degree of bureaucracy within the organization is today perceived to be high and does sometimes receives criticism. This could influence the willingness to join another type of certification which would open up for other systems, for example where the transactions are based on a blockchain solution with a lower degree of bureaucracy.

As mentioned previously in the report, large multinational organizations set ambitious goals for how they and their offerings should become more sustainable. Thus, there is an outcry for a method that quantifies the organization's efforts within this area. In the conducted interviews it was stressed that the most important mission is to ensure sustainable business practices and be able to assure that the used material is possible to recycle or reuse. Recycling extends the fiber base and can help to conserve forest resources, but it is not always clear whether recycled fibers are more sustainable than using virgin fibers according to the interview study.

As stated previously in the report, the report of Damgaard et al. (2015) confirmed that the use of recycled fibers has a lower carbon footprint than using virgin fiber in Sweden. In contrast, according to Johan Granås at Iggesund, their evaluations showed that it was more sustainable to use virgin fibers at their production site than recycled fibers since the lignin from the wood may be used as biofuel and thus avoid the need for external power which is believed to have a greater share of fossil fuels. Additionally, long distance transports would be necessary to provide the needed amount of fibers for the production, transports usually powered by fossil fuels (Granås, 2019 1st of March, Interview). The carbon footprint of using recycled fibers instead of virgin fibers is to a great extent dependent on what type of energy source that is used when producing the paper as well as the type of transport and the proximity to the supply. The report of Damgaard et al. (2015) is based on a handful of general assumptions and it is clearly state that the different processes of pre-treatment, recycling and virgin material production suggest dissimilarities in energy efficiency and emission. Additionally, it is assumed that the mode and distance of transports affect the emissions. Finally, it is emphasized that the type of heat and electricity used for pretreatment, recycling and virgin material production can affect the total amount of carbon emissions. For complementary systems this may be critical, as when recycling is complemented with separate production of heat and electricity. Consequently, there seems to be knowledge gaps regarding the environmental impacts of virgin versus recycled fibers, which is especially important for managers as they chose what material to source.

As the source of energy differs greatly in different countries it consequently affects the assessment of the carbon footprint. Since the choice of recycled fiber over virgin fibers potentially does not guarantee a more sustainable option, at least not when looking at a global market, one could argue that it would be more appropriate to focus on storing the overall carbon footprint on a blockchain instead of focusing on recycled versus virgin fiber. This type of application was also mentioned as desired during the interview study. At IKEA the carbon footprint of cardboard and containerboard packaging is seen as an important parameter upon choosing what packaging material to source. This thesis has focused on the Swedish market, but value chains are global and there is a need to better understand production processes and their emissions to form better sustainability strategies.

As mentioned above the product provenance of a packaging is of importance when packing food or pharmaceuticals due to safety reasons. Thus, one possible field of a blockchain application could be tracking packages used in the food and pharmaceuticals industry. By using a blockchain to store tracking information the risk of damaged or counterfeit products can be reduced as the verification of the supply chain can be done faster. This is of special importance for these two industries where the demand for fast recalls are high for safety reasons. Pilot studies for tracking items using BCT within these fields already exist but the cardboard and containerboard packaging industry could possibly take part and support product safety through their value chain.

Apart from using a blockchain to store information of emissions or tracking packaging that contains food or pharmaceuticals another potential field of application would be using smart contracts to facilitate the trading between different actors in the supply chain. Today the business is built on close relationships and partnerships, to implement smart contracts on a blockchain would be a disruptive solution that helps facilitate more temporary business relationships.

## 5.2 Ease of use

The amount of effort required to learn and use the blockchain technology is evaluated by analyzing the technology itself regarding its complexity and possible implementation challenges. Furthermore, there is an elaboration of the characteristics of the cardboard and containerboard packaging industry and its relations to the ease of using the blockchain technology.

### 5.2.1 **The blockchain technology**

The characteristics of the analyzed technology greatly affects the perceived ease of use. Blockchain enthusiasts argue that blockchain to an extent will break common patterns, or at least help new business models do so. Furthermore, as the technology has a relative advantage compared to other solutions for data storage the speed of adoption of the technology will be higher. But the implementation of blockchain itself also creates a complexity as it requires multiple actors to collaborate and agree upon standards, this hinders the adoption of the technology. Due to the complexity, the observability as well as the communication of the innovation is negatively affected.

The technology has received a large hype though and has over the last couple of years been communicated via mass media, but the hype has peaked (Gartner, 2017). To be able to use a technology it must be understood by its users. An identified challenge of implementing blockchain is that there is a general lack of understanding. Hence, there is a potential risk that actors do not trust the technology which in turn may lead to them not trusting the information on the blockchain. Moreover, there are currently no common standard in place on how a blockchain technology should be implemented which is seen as an obstacle for implementing the technology.

Lastly, the implementation of blockchain demands new IT-systems and likely new organizational structures which is estimated to be both expensive and challenging. However, the technology promotes transparency which greatly aligns with the interest and goals of many organizations.

To evaluate blockchain technology and its ease to use, the progress of adoption in other industries was examined. When exploring the literature published in 2018 within the field of blockchain and supply chains it was realized that more articles had been published in one year than what had been published during the preceding ten years. Thus, it seemed reasonable to conduct a new literature study to explore potential progress and current state of the art. A comparison of the identified drivers, opportunities and challenges of implementing blockchain is shown in Table 5.2. The results from this literature study were to a great extent similar to the study conducted by Wang, Han and Beynon-Davies (2018). The exact same words are not used to explain the findings, but the meaning of the different drivers, opportunities and challenges are perceived to be equivalent in the two different studies. For example, is the need for seamless networks found by Wang, Han and Beynon-Davies, interpreted to have a very similar meaning as supply chain optimization. Furthermore, both studies only describe pilot projects of blockchain implementation and to a large extent the very same examples were found in the two different studies.

**gra**

| | **Literature study from 2018 by Wang, Han and Beynon-Davies** | **Literature study from 2019 by Ragnarsson and Trulsson** |
|---|---|---|
| **Drivers for blockchain deployment in SCM** | • Trust is driving interest in BCT within SCM<br>• Need for seamless networks<br>• Reliability and security of information<br>• Product safety, authenticity and legitimacy | • Lack of trust<br>• Supply chain optimization<br>• Transparency for customers |
| **Opportunities of BCT for SCM** | • Extended visibility and product traceability<br>• Supply chain digitalization and disintermediation<br>• Improved data security for information sharing<br>• Smart contracts | • Reduced transaction costs<br>• Transparency<br>• Reduced ability to cheat |
| **Challenges and barriers for further diffusion in SCM** | • Operational<br>• Technological<br>• Organizational and user-related | • High implementation cost<br>• Lack of common standard<br>• Organizational change |

Obviously, a great amount of literature is constantly being published within the area of blockchain and supply chains but as it does not exist extensive roll outs of the technology for the common man the acceptance of the technology is affected.

To summarize, the perceived ease of use is negatively affected by the complexity of the technology and the fact that there is an identified lack of understanding of the blockchain. Furthermore, there is a lack of scaled up implementations which one can learn from and thereby facilitate the learning process. The absence of a common standard as identified by the literature review is also an obstacle for the ease of using the blockchain technology. An implementation of blockchain would demand tremendous efforts of coordination between all the different actors of the value chain and potential optimizations might be a long time coming. However, the technology provides an opportunity of increased transparency which may increase the satisfaction of learning the new technology.

### 5.2.2 Characteristics of the cardboard and containerboard industry

The ease of using blockchain technology is not only dependent on the actual technology but also the characteristics of the people and organizations who are expected to adopt the technology. In general, when examining the adoption of blockchain across industries the technology is perceived to be faced with crossing the chasm between early adopters who are the technology enthusiasts and the early majority who are the pragmatists. As the authors have created their perception of the technology adoption by conducting interviews, reading papers and attending conferences it is evident that the blockchain community is a kind of bubble for its enthusiasts, that projects are mainly of pilot nature and that they often result in a need for further scaling but seldom reach the full potential that is often advocated. Thus, the blockchain industry mainly consists of innovators and is struggling to gain a greater traction needed for wider adoption.

Naturally, most applications of blockchain exists within the financial sector as the technology stems from the industry, but as argued there exists deployment of the technology within supply chains for different types of applications. Most of the interviewed organizations from the cardboard and containerboard packaging industry have not yet started to explore the technology, only four out of fifteen interviewees were aware of any type of BCT projects within their organizations. None of these projects concerned the actual composition of a package as this thesis aimed to explore. Consequently, it seems unlikely that the industry would start to adopt the technology without available larger scale success cases from other supply chains, even though many actors want to promote transparency and sustainable business practice.

The fact that the cardboard and containerboard industry is perceived to be among the late ones to adopt new technology is not favoring the current effort needed to use the technology. Efforts to start exploring and potentially implementing the technology within an organization would risk tension and friction. Another hinder would be that organizations in the cardboard and containerboard industry, are perceived to not be interested in providing education of blockchain technology which heavily increases that amount of effort needed for the employees to understand blockchain.

## 5.3 Contributions

The goal of this thesis was to explore if blockchain technology can offer the value chain a viable solution to improve traceability of recycled cardboard and containerboard packaging. This is of interest as large multinational brand owners formulate sustainability visions and more extensive legislation is introduced by the European Commission concerning the amount of used recycled material as well how recyclable the material is.

### 5.3.1 Contributions to academia

The literature review made by the authors is one of the key parts of the thesis and it does not only play an important role for this paper as it supports the analysis of the interview studies. Additionally, it also verifies the findings made by Wang, Han and Beynon-Davies (2018) since it finds out that to a great extent the same cases are used during the time period between January 2018 and January 2019 and the results are similar. As emphasized earlier, the literature on blockchain implementations within supply chains has increased in numbers greatly recently as the technology is trying to gain a wider adoption. Consequently, the literature review helps to understand that even though the field has received far more interest lately the same findings can be made therefore the above-mentioned article is still relevant.

The thesis also provides an extensive explanation of the industry for cardboard and containerboard packaging and its current state as well as an explanation of current traceability and certification processes.

As blockchain is still a novel technology and the authors were more or less unfamiliar with the technology a large part of the frame of reference Chapter explains the technology. This Chapter together with the specific study of implementing the technology in the cardboard and containerboard packaging industry helps to both spread and increase the knowledge of the blockchain technology and its potential use.

### 5.3.2 Contributions to industry

New areas of research have been found which could help form the future research agenda for projects aimed to increase the traceability and transparency within the cardboard and containerboard packaging industry. The suggested areas of future of research can also help RISE form their strategy for knowledge acquisition and development to maintain their offers of unique expertise that help the business community ensure competitiveness and sustainability to future-proof technologies, products and services.

## 5.4 Limitations

The conclusions drawn in this report may be applied on the overall cardboard and containerboard packaging industry as well as other industries which share similarities. However, it can only be assured that the conclusions are legitimate for the specific actors that have been included in the interview study. Furthermore, there is a risk that the authors own interpretations and viewpoints has, to some extent, affected the interview study as they interpreted the answers of the interviewees and codified the results. Nevertheless, the interviewees have had the opportunity to assure that their statements were accurately interpreted and comment upon the statements found in the results Chapter.

The attitudes of the consumers are in this thesis represented by a report published by Procarton (2018). It may be perceived as a limitation to only use one source to represent the consumers. However, the report is based on a survey conducted with 7000 respondents and was therefore believed to be sufficient to use as a base. Furthermore, the report by Procarton cover consumers from France, Germany, Italy, Poland, Spain, Turkey and United Kingdom. This thesis focuses on the Swedish market, but it is assumed that the attitudes identified by Procarton is applicable on Swedish consumers as well.

Lastly, the authors analyzed the answers of the respondents of the explorative interviews in order to apply them to the Technology Acceptance Model and evaluate the usefulness as well as the ease of use. Consequently, it is not directly the interviewees perception which is represented in the analysis but rather the authors interpretation.

# 6 Conclusion

*This Chapter presents the conclusion of the thesis as well as a verification of the conclusion.*

## 6.1 Blockchains viability to improve traceability of recycled fibers

Using the technology acceptance model to analyze the results of our studies the conclusion is that blockchain cannot offer a viable solution to improve traceability of recycled cardboard and containerboard packaging today. The usefulness of implementing a blockchain solution is not perceived to be high enough for three main reasons:

- The interview study showed that only two out of the three most important drivers for blockchain adoption were present within the cardboard and containerboard industry. Most importantly the main driver, lack of trust, was not present within the industry as it heavily depends on the trust between actors. As trust is present a simpler technology for a shared database could help to solve the challenges of supply chain optimization and customer/consumer transparency.
- A cardboard or containerboard packaging has a relatively low monetary value and its characteristics makes it hard to cheat with ingoing components. Compared to products in industries where blockchain solutions have been thought of as useful before, according to the literature study, not many similarities are shared. In cases where blockchain has been used for products with low monetary value the provenance has been of importance to ensure safe products for the consumer. The provenance of packaging is important when packing food or pharmaceuticals. However, these industries are exposed to extensive legislation which is seen as the foundation for trust.

- To specifically determine the distribution of recycled fibers versus virgin fibers in a cardboard or containerboard packaging is not feasible. To link physical and digital good is essential for a blockchain solution on an individual fiber level. One package contains an enormous amount of fibers which would make it financially and technically difficult to track the origin of every single fiber.

The ease of using the blockchain technology in the cardboard and containerboard industry is not perceived to reach a level high enough to consider implementing blockchain today, this because:

- The technology itself is complex and in the literature study it was identified that a challenge related to the technology adoption is a lack of understanding. There is an absence of a common standards to use when implementing the technology which would demands great coordination between the different actors of the value chain.
- It would demand a great amount of effort and education to understand the possibilities of the technology since there are no available larger scale success cases from other supply chains.

As it has been stated that it is not viable to track individual fibers today other possible fields of application has been elaborated on. The conclusion is that it would be more appropriate to focus on storing environmental metrics as for example the overall carbon footprint on a blockchain. This since there are conflicting viewpoints as found by this study whether the choice of recycled fiber over virgin fibers does guarantee a more sustainable alternative.

## 6.2 Verification of conclusion

To bring a greater legitimacy to the conclusion of the thesis, two experts in blockchain technology got the opportunity to leave feedback. Both Jonatan Bergquist, founding member of European Blockchain Association and Blockchain Architect at Datarella as well as Fabian Portmann, Senior Consultant in Blockchain at IBM find the conclusion reasonable (Bergquist, 2019 8th of May, E-mail; Portmann, 2019 21st of May, E-Mail)

# 7 Future research

There are ambitious regulations and targets on the amount of recycled cardboard and containerboard packaging and actors mainly rely on contracts and trust for the product composition, but it has shown that it is problematic to follow up and verify information as it often requires organizations to allocate resources to perform sample checks on the site of production. Additionally, the studies showed that especially for packaging material used for foods it is important to be able to trace the material through the value chain to ensure product safety. This is possible today, but it takes time to trace batches of material, this case is similar to ones where organizations explored how blockchain technology can help improve the speed of traceability within supply chains. For example, where Walmart and IBM have aimed to identify infected supply faster, easier and with greater precision (Miller, 2018). One future area of research is consequently to better understand if it is of interest to improve the speed of traceability for cardboard and containerboard packaging, especially for the one in contact with foods and whether blockchain can help to improve the process or what other technologies might be better suited.

As trust forms the basis for the long-lasting business relationships within the industry for cardboard and containerboard packaging there might be opportunities for business models based on smart contracts supported by blockchain technology to enable secure transactions. Thus, it is suggested to do more research on how smart contracts can form new types of short term and secure business relationships that potentially could reduce the transaction cost related to building trust, ensure compliance and increase competitiveness.

Improved transparency is mentioned as a possible method to increase competitiveness among several actors of the value chain for cardboard or containerboard. The aim of the research questions for this thesis was to explore how recycled fibers could help organizations become more transparent as a part of their respective sustainability visions. As the research evolved it was realized that the composition of recycled and virgin fibers of a cardboard or containerboard package is not the best metric to promote sustainability. Some actors like IKEA want to use carbon footprint as one of the most important metrics for deciding upon suppliers. Iggesund wishes to increase their transparency and show how their process based on renewable materials and energy is one way they try to increase their competitiveness. Future research can thus aim at exploring how information of environmental metrics like the carbon footprint can be derived through the value chain in better way, possibly supported by blockchain technology to enable new pricing models, ways of forming business contracts and possibly impose taxes. Most likely there are mixed views of environmental metrics and carbon footprint as mentioned by some of the interviewees might not be the best and future research must bear this in mind.

Many of our interviewees emphasized that there is a large focus on circularity and recycling which is not a straightforward process as it presents many challenges. For example, it was evident that recycle friendly design of packaging, so that different material can easily be separated, is an area of interest. Recycling is also troublesome as the process can lead to the generation of toxins in material and thus there is an outcry for increased traceability to better understand the process and prevent scandals for brand owners who seek to increase their use of recycled material. Consequently, future research could aim to better understand the recycling process and its consequences by digitizing the value chain as way to ensure the sustainability agenda of organizations.

As blockchain implementations across actors in value chains requires extensive coordination it is important to bear in mind and further explore how this coordination can be done in an effective and suitable way. Consequently further research might investigate how the coordination can be done in the best way, RISE in their role as an innovation partner that works in collaboration with and on behalf of the private and public sector and academia, has a promising position to be a key player for this coordination and thus might explore how they should fill this role in the best way.

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## 8.1 Interviews

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# **Appendix A** Descriptive interviews

| *Name* | *Position* | *Date* | *Type of interview* |
|---|---|---|---|
| Lena Jönsson | Lead auditor for FSC and PEFC Certification at RISE | 30th of January | In person |
| Tomas Anderson | Senior Business Director at RISE Bioeconomy/Papermaking & Packaging | 6th of February | Telephone |
| Erik Rissanen | Chief Technical Officer at Blockchain Innovation Centre, RISE | 13th of February | In person |
| Cathrine Löfgren | Project Manager Sustainability at RISE | 13th of February | In person |
| Astrid Odeberg Glasenapp | PhD MBA at RISE Bioeconomy/Papermaking and Packaging | 13th of February | In person |
| Sofia Backéus | Project manager at SIS, Environment and Consumer | 14th of February | Telephone |
| Kennert Johansson | Senior project manager at RISE Bioeconomy and Acting Secretary General at CEPI Eurokraft | 15th of February | In person |
| Anna Rydberg | R&I Manager innovative techniques and processes, Agrifood & Biosciences at RISE | 15th of February | In person |
| Olof Nyström | Head of member community at Packbridge | 22nd of February | In person |
| Lisa Schwarz Bour | Textile Recycling Area Manager at RISE | 25th of February | Telephone |
| Anders Lindberg | Project manager at SIS | 26th of February | Telephone |
| Fabian Portmann | Senior Consultant, Blockchain at IBM | 6th of March/21st of May | Telephone/E-mail |

| | | | |
|---|---|---|---|
| Jonatan Bergquist | Founding member of European Blockchain Association and Blockchain Architect at Datarella | 28th of March/8th of May | In person/E-mail |

# **Appendix B** Explorative Interviews

| *Name* | *Position* | *Date* | *Type of interview* |
|---|---|---|---|
| Johan Granås | Head of Sustainability at Iggesund | 1st of March | Telephone |
| Martin Palmér | Head of Paper at Stena Recycling AB | 4th of March | Telephone |
| Julian Fox | Director, Sourcing and Manufacturing, Tetra Pak International | 5th of March | In person |
| Krassimira Kazashka | Technical director at FEFCO | 6th of March | Telephone |
| Einar Ahlström | Material Specialist at FTI | 6th of March | Telephone |
| Jon Djerf | Advisor for recycling, collection and transport, Avfall Sverige | 7th of March | Telephone |
| Sofia Erixson | Packaging Developer, Orkla Foods | 14th of March | Telephone |
| Ann Lorentzon | Project Manager at RISE Bioeconomy | 18th of March | In person |
| Karolin Catela | Business Manager Traceability, GS1 Sweden | 19th of March | In person |
| Martin Hörberg | Head of Packaging and Traceability, ICA Group AB | 19th of March | Telephone |
| Sandra Pousette | Senior Project Manager, RISE | 19th of March | In person |
| Sofia Lönegård | Sustainable Business & Communications, Unilever Nordics | 20th of March | E-mail |
| Per Funkquist | Business developer forest certification at BillerudKorsnäs | 21st of March | In person |
| Diana Seleznova | Sustainability developer at packaging and handling materials, IKEA Purchasing Services | 21st of March | Telephone |
| Zsófia Réger | Packaging Developer, Axfood | 3rd of April | E-mail |

# **Appendix C** Generic interview guide

- Introduction of us and our project
- Tell us about the organization and your role
- What are the most prominent trends in your area of trade?
- What are the key areas of interest in your business today
- Who are your key customers and suppliers?
- How would you describe trust within your value chain?
    - What certificates/markings exist in the value chain?
    - Do you trust the claims of product quality/the existing markings etc.?
    - Have you perceived there are some cheating actors in the value chain?
- Is there any existing sort of traceability in the value chain?
    - Are there any incentives for increased traceability?
- How does the organization position itself to blockchain technology?
- Are there any blockchain initiatives within the organization?
    - What are the initiatives?
- What is your view of blockchain technology?
    - Do you believe it could be an application that could help to increase the traceability of cardboard or containerboard packaging?
- What type of data would you not like to put on a blockchain?

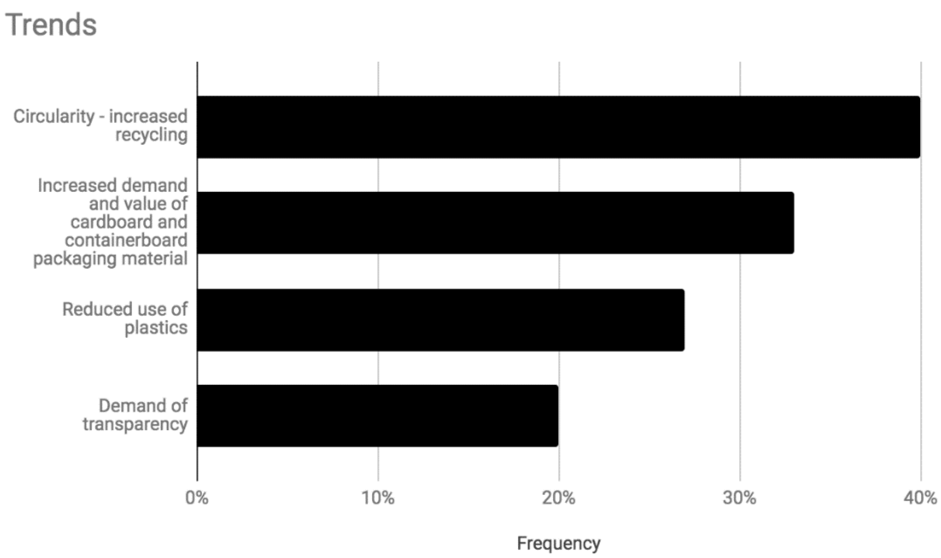
# **Appendix D** List of literature for the literature review

| Title | Author(s) | Year |
| --- | --- | --- |
| Applying blockchain technology: Evidence from Norwegian companies | Anne H. Gausdal, Karen V. Czachorowski, Marina Z. Solesvik | 2018 |
| Blockchain in logistics and supply chain: a lean approach for designing real-world use cases | Guido Perboli, Stefano Musso, Mariangela Rosano | 2018 |
| Blockchain practices, potentials, and perspectives in greening supply chains | Mahtab Kouhizadeh, Joseph Sarkis | 2018 |
| Blockchain technology and its relationship to sustainable supply chain management | Sara Saberi, Mahtab Kouhizadeh, Joseph Sarkis, Lejia Shen | 2018 |
| Blockchain technology for enhancing supply chain resilience | Hokey Min | 2019 |
| Blockchain technology in the energy sector: A systematic review of challenges and opportunities | Merlinda Andoni, Valentin Robu, David Flynn, Simone Abram, Dale Geach, David Jenkins, Peter McCallum and Andrew Peacock | 2019 |
| Blockchain-based traceability in Agri-food supply chain management: a practical implementation | Miguel Pincheira Caro, Muhammad Salek Ali, Massimo Vecchio. Raffaele Giaffreda | 2018 |
| Blockchain: What It Is, What It Does, and Why You Probably Don't Need One | Andolfatto, David | 2018 |

| | | |
|---|---|---|
| Blockchain's roles in meeting key supply chain management objectives | Nir Kshetri | 2018 |
| CoC: A Unified Distributed Ledger Based Supply Chain Management System | Zhimin Gao, Lei Xu, Lin Chen, Xi Zhao, Yang Lu, Weidong Shi | 2018 |
| Distributed Ledger Technology for Document and Workflow Management in Trade and Logistics | Ziyuan Wang, Dain Yap Liffman, Dileban Karunamoorthy, Ermyas Abebe | 2018 |
| Do you need a Blockchain? | Karl Wüst, Arthur Gervais | 2018 |
| Exploring the applicability of blockchain technology to enhance manufacturing supply chains in the composite materials industry | Adrian E. Coronado Mondragon, Christian E. Coronado Mondragon , Etienne S Coronado | 2018 |
| How blockchain improves the supply chain: case study alimentary supply chain | Roberto Casado-Vara, Javier Prieto, Fernando De la Prieta and Juan M Corchado | 2018 |
| Opportunities for Use of Blockchain Technology in Medicine | Igor Radanović, Robert Likić | 2018 |
| ProductChain: Scalable Blockchain Framework to Support Provenance in Supply Chains | Sidra Malik, Salil S. Kanhere, Raja Jurdak | 2018 |
| Research on the Application of Blockchain in the Traceability System of Agricultural Products | Jing Li, Xinyan Wang | 2018 |
| Supply Chain Management based on Blockchain: A Systematic Mapping Study | Youness Tribis, Abdelali El Bouchti and Houssine Bouayad | 2018 |
| The impact of the blockchain on the supply chain: a theory-based research framework and a call for action | Treiblmaier, Horst | 2018 |

# **Appendix E** Results from interview study

## E.1 Trends

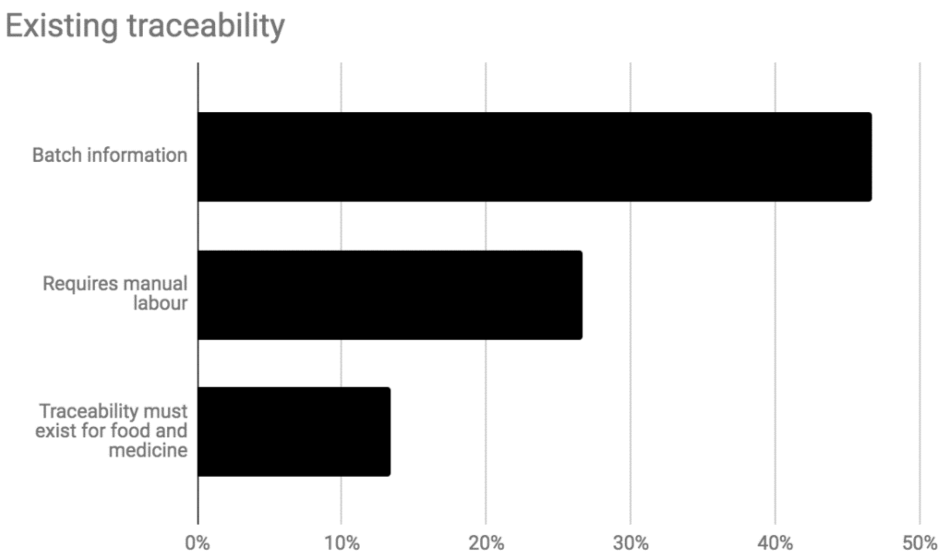



| **Source** |
|---|
| **Johan Granås, Iggesund** |
| Circularity - increased recycling |
| Reduced use of plastics |
| |
| **Martin Palmér, Stena Recycling** |
| |
| **Julian Fox, Tetra Pak** |

| |
|---|
| |
| **Krassimira Kazashka, FEFCO** |
| Circularity - increased recycling |
| Increased demand and value of cardboard and containerboard packaging material |
| |
| **Einar Ahlström, FTI** |
| Circularity - increased recycling |
| |
| **Jon Djerf, Avfall Sverige** |
| Increased demand and value of cardboard and containerboard packaging material |
| Reduced use of plastics |
| Demand of transparency |
| |
| **Sofia Erixson, Orkla Foods** |
| Circularity - increased recycling |
| Increased demand and value of cardboard and containerboard packaging material |
| |
| **Ann Lorentzon, RISE** |
| Reduced use of plastics |
| |
| **Martin Hörberg, ICA Group** |
| Demand of transparency |
| |
| **Karolin Catela, GS1** |
| |
| **Diana Seleznova, IKEA** |
| Circularity - increased recycling |
| Increased demand and value of cardboard and containerboard packaging material |

| |
|---|
| |
| **Per Funkquist, BillerudKorsnäs** |
| Circularity - increased recycling |
| Increased demand and value of cardboard and containerboard packaging material |
| |
| **Sandra Pousette, RISE** |
| Reduced use of plastics |
| Demand of transparency |
| |
| **Zsofia Regér, Axfood** |
| |
| **Sofia Lönegård, Unilever** |
| |

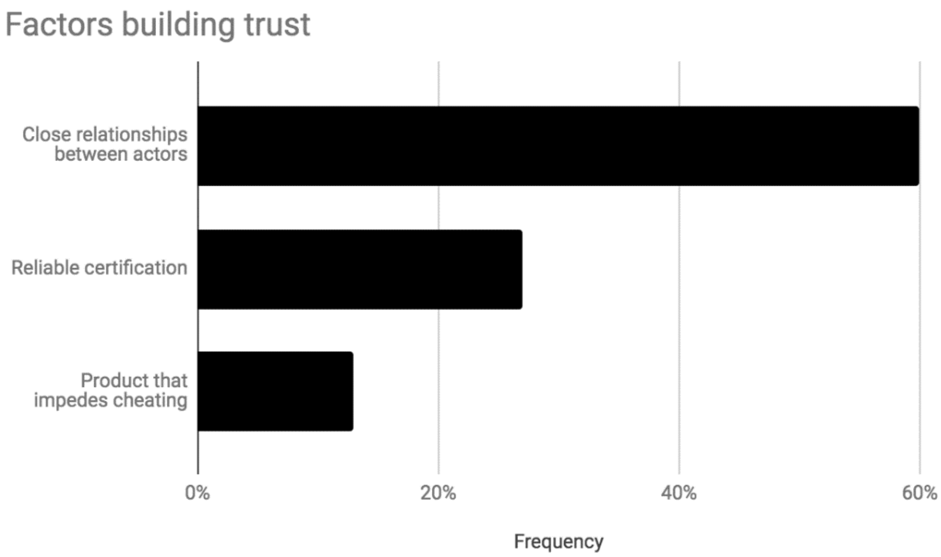
## E.2 Existing traceability



| Source |
| --- |
| **Johan Granås, Iggesund** |
| Batch information |
| |
| **Martin Palmér, Stena Recycling** |
| |
| **Julian Fox, Tetra Pak** |
| Batch information |
| Requires manual labour |
| |
| **Krassimira Kazashka, FEFCO** |
| Traceability must exist for food and medicine |
| |
| **Einar Ahlström, FTI** |
| Batch information |
| |
| **Jon Djerf, Avfall Sverige** |
| |
| **Sofia Erixson, Orkla Foods** |
| Batch information |
| Requires manual labour |
| |
| **Ann Lorentzon, RISE** |
| Requires manual labour |
| Traceability must exist for food and medicine |
| |
| **Martin Hörberg, ICA Group** |
| Batch information |

| |
|---|
| |
| **Karolin Catela, GS1** |
| |
| **Diana Seleznova, IKEA** |
| Batch information |
| |
| **Per Funkquist, BillerudKorsnäs** |
| Batch information |
| |
| **Sandra Pousette, RISE** |
| |
| **Zsofia Regér, Axfood** |
| Requires manual labour |
| |
| **Sofia Lönegård, Unilever** |
| |

## E.3 Factors building trust




| |
|---|
| **Source** |
| **Johan Granås, Iggesund** |
| Close relationships |
| Reliable certification |
| |
| **Martin Palmér, Stena Recycling** |
| Product that impedes cheating |
| |
| **Julian Fox, Tetra Pak** |
| Reliable certification |
| |
| **Krassimira Kazashka, FEFCO** |
| Close relationships |
| Reliable certification |

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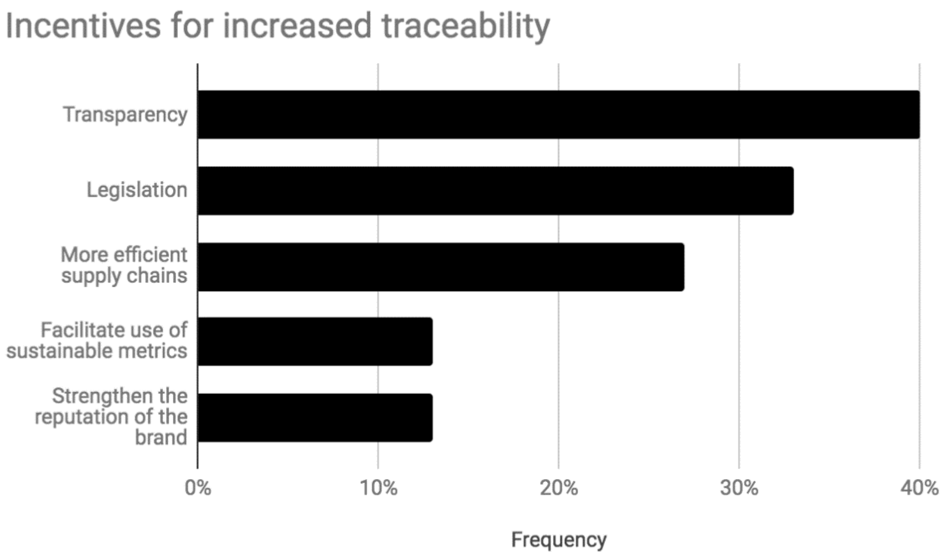
|---|
| |
| **Einar Ahlström, FTI** |
| |
| **Jon Djerf, Avfall Sverige** |
| Product that impedes cheating |
| |
| **Sofia Erixon, Orkla Foods** |
| Close relationships |
| |
| **Ann Lorentzon, RISE** |
| Close relationships |
| |
| **Martin Hörberg, ICA Group** |
| Close relationships |
| |
| **Karolin Catela, GS1** |
| |
| **Diana Seleznova, IKEA** |
| Close relationships |
| |
| **Per Funkquist, BillerudKorsnäs** |
| Reliable certification |
| |
| **Sandra Pousette, RISE** |
| Close relationships |
| |
| **Zsofia Regér, Axfood** |
| Close relationships |

| |
|---|
| |
| **Sofia Lönegård, Unilever** |
| Close relationships |
| |

## E.4 Incentives for increased traceability

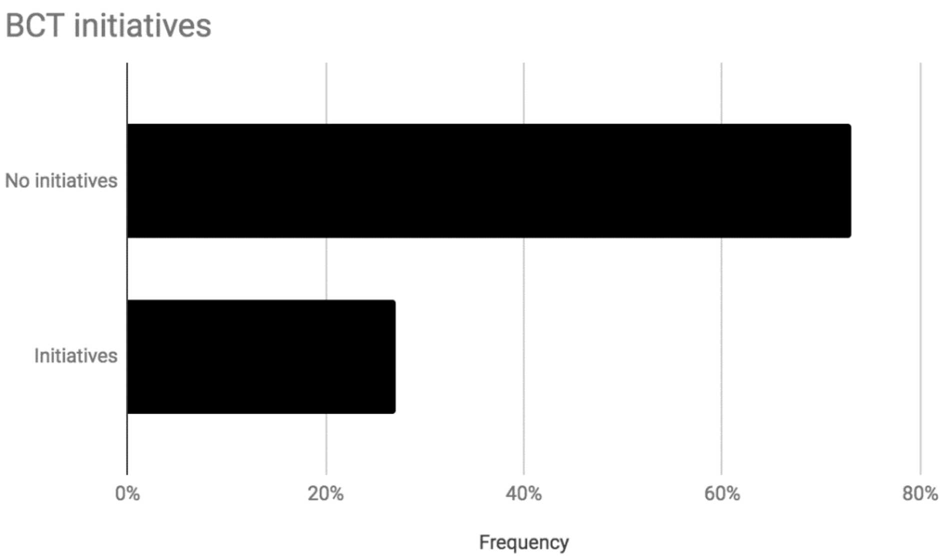



| **Source** |
|---|
| **Johan Granås, Iggesund** |
| Transparency |
| Facilitate use of sustainable metrics |
| Strengthen the reputation of the brand |
| |
| **Martin Palmér, Stena Recycling** |
| Legislation |
| |

| |
|---|
| **Julian Fox, Tetra Pak** |
| Transparency |
| More efficient supply chains |
| |
| **Krassimira Kazashka, FEFCO** |
| |
| **Einar Ahlström, FTI** |
| Transparency |
| Legislation |
| |
| **Jon Djerf, Avfall Sverige** |
| |
| **Sofia Erixon, Orkla Foods** |
| Transparency |
| |
| **Ann Lorentzon, RISE** |
| |
| **Martin Hörberg, ICA Group** |
| Transparency |
| Legislation |
| Strengthen the reputation of the brand |
| |
| **Karolin Catela, GS1** |
| Legislation |
| More efficient supply chains |
| |
| **Diana Seleznova, IKEA** |
| More efficient supply chain |

| |
|---|
| Facilitate use of sustainable metrics |
| |
| **Per Funkquist, BillerudKorsnäs** |
| Transparency |
| |
| **Sandra Pousette, RISE** |
| Legislation |
| |
| **Zsofia Regér, Axfood** |
| More efficient supply chain |
| |
| **Sofia Lönegård, Unilever** |
| |

## E.5 Blockchain initiatives



| Source |
| --- |
| **Johan Granås, Iggesund** |
| No initiatives |
| |
| **Martin Palmér, Stena Recycling** |
| No initiatives |
| |
| **Julian Fox, Tetra Pak** |
| Initiatives |
| |
| **Krassimira Kazashka, FEFCO** |
| No initiatives |
| |
| **Einar Ahlström, FTI** |
| No initiatives |
| |
| **Jon Djerf, Avfall Sverige** |
| No initiatives |
| |
| **Sofia Erixon, Orkla Foods** |
| No initiatives |
| |
| **Ann Lorentzon, RISE** |
| No initiatives |
| |
| **Martin Hörberg, ICA Group** |
| No initiatives |
| |

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|---|
| **Karolin Catela, GS1** |
| Initiatives |
| |
| **Diana Seleznova, IKEA** |
| No initiatives |
| |
| **Per Funkquist, BillerudKorsnäs** |
| No initiatives |
| |
| **Sandra Pousette, RISE** |
| No initiatives |
| |
| **Zsofia Regér, Axfood** |
| Initiatives |
| |
| **Sofia Lönegård, Unilever** |
| Initiatives |
| |