Aalto University
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Increased transparency and prevention of unethical actions in the textile industry's supply chain through blockchain

Literature review

Bachelor's Thesis
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23.5.2019
ISM Program

Approved in the Department of Information and Service Management
xx.xx.20xx and awarded the grade

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1 Introduction

The worth of the global retail fashion market today is over $1.3 trillion (Ethical Fashion Group Ltd, 2017) and about 60 to 75 million people, from which over 75% are women, are employed by the industry (Stotz and Kane, 2015). Many industries struggle with unethical suppliers and lack of transparency, but especially the fashion industry has become aware of the issues in recent years and many players are working actively towards more transparent supply chains. The scale of the fashion industry makes it a significant player in the world development, especially in development of developing countries, state of world poverty and overall nation's well-being.

Most of the fashion industry's ethical issues are due to questionable supply chains, which are not transparent for consumers, and can't be verified as sustainable and ethical. The key problems arising from the industry are not in apparel manufacturing suppliers (Tier 1), but mainly in other tier suppliers. Today companies can have relative transparent and direct relationships with the tier 1 suppliers, but it is not as simple with other tier suppliers, as the other tier relationships are managed through the Tier 1 supplier. In 2018, 35% of brands published their Tier 1 supplier list, but only 19% of the brands published information of their raw material suppliers (tier 2, 3 or 4 suppliers) (Fashion Revolution Foundation, 2018). In 2018, one of world's largest fast fashion brands, H&M reported that 100% of their tier-one Bangladesh factory workers are already represented by democratically elected representatives. But this approach takes into account solely only the tier 1 H&M factories in Bangladesh (H&M, 2018). Lindex has reported in 2017 that they work actively to ensure their production follows all of their policies through code of conduct, self-assessment and factory audits, but this, again, applies only to tier 1 suppliers. Lindex has only recently started to work with the ethicality and sustainability of tier 2 suppliers (Sellberg *et al.*, 2017).

One of the reasons why more and more companies are paying increasing amont of attention to their suppliers and the supply chain processes, is due to increasing amount of regulations, certificates and laws. In addition to these, the industry is witnessing a change in consumer behavior. In 2018 61% of consumers were interested to know what actions fashion brands are taking to protect their worker's human rights. In the same survey 77% of consumers agreed, that fashion brands should be required by law to respect human rights of all workers (Fashion Revolution, 2018). In recent years the industry has put pressure on companies to talk and editorialise more on their supply

chains. One of the indicators of this discussion has been the Rana Plaza factory collapse in 2013. The collapse of this Tier 1 garment factory, producer of many western fast fashion brands, killed over 1,100 garment employees in Bangladesh. This catastrophe affected the industry, but it also affected largely the consumers and made them much more aware of the textile industry and its dark side. In the future the question will not only be about following the legislations or avoiding involvement in a catastrophe like Rana Plaza, but simply customer acquisition. Fashion companies need to pay more attention to their supply chains and bring transparency for all counterparts.

The reason for the lack of transparency during the whole supply chain, from cotton farming to fabric weaving and sewing clothing, is mainly due to the relations and communication between the brand and the suppliers. It is hard to receive up-to-date and reliable information from the suppliers about the provenance of the used materials, the working conditions of workers and factory conditions. In the case information is received, there is still a great possibility for it to be fake or extremely polished from the reality. Many brands make audits to their factories to become aware of the factory and worker conditions, but because these are mainly pre-agreed meetings, suppliers can polish the factory and directly affect the opinions of the workers.

The textile and fashion industry generates significant profits and employes millions of workers, but still there hasn't emerged a solution to avoid forced labour, to pay living wages for the workers or to guarantee safe working conditions for the workers. Newer technologies, such as blockchain, RFID codes and tracking sensors, could bring significant amount of transparency, automation and easement to the supply chain process and communication between suppliers and brands, as the information would become more reliable, easy to access and up to date. The transparency and amount of information increased by these technologies would lead to better understanding of the processes by consumers and brands, and eventually to actions leading towards eliminating unethical producers from textile industry's supply chains. This thesis paper will focus on researching what kind of affects blockchain technology can have on textile industry's supply chains.

1.1 Research objectives and research questions

This thesis paper will look into unethical affairs in textile industry's supply chain and identify three unethical procedures, which are most widely and tremendously affecting the lives of garment workers. This identification has taken in to account the amount of

people these procedures affect, with this compared to the magnitude of the procedure, as in how serious consequences these procedures can have in the lives of the workers. This research is being enlightened in the chapter 2. After the identification, the research will define how these three key unethical procedures could be minimized and eventually removed from textile industry's supply chains with the use of blockchain.

There will be two research questions for this thesis paper. The second question includes also a sub-question, which will be discussed in the paper, but deeper research will be left for future research. 1) What is the tier structure of textile industry's supply chain and what are the key three ethical problems in these supply chains? 2) What kind of benefits would the implementation of blockchain technology to textile industry's supply chain bring in terms of increasing transparency and minimizing unethical actions? 2.1) How an un-truthful information input to the blockchain technology during the supply chain management can be minimized?

1.2 Scope of research

The scope of this research will focus and make assumptions on textile industry's fast fashion companies, who have released their Tier 1 supplier list in the past. We can assume, that these companies are working actively towards more transparent supply chains and are willing to better their procedures. The research will take a broader look into the supply chain practices of these companies. Mainly the research will focus on the blockchain technology itself and how this technology can help the companies develop their practices further on the aspect of transparency and ethicality.

The research will not focus on companies who have not released their Tier 1 supplier list publicly. Every textile company has access to their Tier 1 supplier list, as these suppliers are their point of contact in production. In case the company hasn't released this Tier 1 suppliet list, we can assume, that these companies work intentionally unsustainably and without transparency to the end-customer. Blockchain technology requires intentional change in company processes and values in order to gain added value from the implementation of the technology. Blockchain technology can bring tremendous improvements to the transparency and amount of information, but in case the company in itself isn't willing to make changes towards more sustainable and ethical supply chains, blockchain will not help these companies.

1.3 Structure of research

The research of the thesis will start in chapter 3 by looking in more depth to the textile industry's supply chain and enlightening the structure of the usual supply chain. Along with the specific structure of the supply chain, there will be identification of the three most magnicifent ethical problems which the textile industry is struggling with every day. These three main problems will be opened up more precisely in the same chapter.

After the industry analysis, the research will move into blockchain technology. The research will start by looking at the technology from a broader perspective: enlightening the history and the technical functions behind the technology. This paper will focus more precisely in the anonymity of the blockchain technology, as that is one of the key factors concerning the research. Blockchain utilization in the supply chain industry, outside of the textile industry, will be researched also briefly.

After the analysis and research, the results on the use of blockchain technology in textile industry's supply chain will be presented. The focus will be very concretely how the technology can be implemented to the industry and how the process can be made more transparent to the brand and consumers. To support the results, there will be an illustrative case to help the reader understand real-life implementation possibilities. The disadvantages and difficulties of the implementation of the technology will be covered after the results. The last chapter discusses about the improvements this research can bring for textile industry companies. In addition, the limitations of this research will be covered and further research possibilities in the field outlined.

Through out the thesis, the supply chain processes and the changes blockchain can have on them are visualized with illustrative graphs.

1.4 Methodology

This thesis was conducted as a literature review. For information research has been used Scopus, Web of Science and Google Scholar. As the thesis presents the state of the textile industry's supply chain functions and ethicality, additionally to research papers, there has been utilization of numerous textile industry reports as the fundamental base of the Thesis.

There are two important research sources, that were extremely relevant in terms of the Thesis paper. The first one is the "Fashion Transparency Index 2018", conducted by

Fashion Revolution. This report showcases all significant fast fashion brands, who have released their Tier 1 supplier list in the previous year. This Thesis is based on the brands who have released their lists, and this makes the Thesis results and conclusions suitable for these companies and companies working in similar ways to them. Another important resource has been the white paper written by Provenance team, an UK based startup working on supply chain transparency and blockchain. The Provenance technology is being presented as an illustrative case example in the results.

There are very few research papers conducted previously considering exactly the topic. Research can be found on blockchain implementation to supply chains in general, but very few of those consider the ethicality of the supply chains. More than that, it focuses on efficiency of processes and insurance of authencity. Significant amount of research was conducted on the provenance of food and how blockchain could bring more transparency for the field, but the research didn't focus exactly on minimizing unethical actions considering the workers well-being. Here the main painpoint was rather insuring the country of origin of the product, what has been fed to the animal in case of meat products, has there been fertilizes used in case of wheats/vegetables etc. Some of these factors are linked to ethical actions but are not in the core of ensuring the worker's safety. When looking at the research from broader perspective, there is a lot of research conducted in blockchain technology.

1.5 Glossary

Tier 1-4 = Different tiers represent the different producers in the textile industry's supply chain. Tier 4 represents the raw material producer, tier 3 the spinning mill, tier 2 the weaving/knitting mill and tier 1 the garment manufacturer.

Spinning mill = Textile industry's tier 3 producer. In spinning mill, the raw material is spun to yarn.

Weawing mill = Textile industry's tier 2 producer. In weaving mill, the yarn from tier 3 producer is woven into textile.

Knitting mill = Textile industry's tier 2 producer. In knitting mill, the yarn from tier 3 producer is knitted into textile.

Fast fashion = A form of fashion which is based on low prices, continuous new collections and rapid rotation of clothing. Brands like H&M, Zara and Primark are one of the largest fast fashion brands. In fast fashion companies, new clothes and collections can be introduced as fast as once in a week.

Forced labour = An unethical procedure in textile industry's supply chain. Forced labour covers situation where workers are forced to work against their will, but it also covers factors like verbal abuse, physical and sexual violence, intimidation, threats and restriction of movement.

Child labour = An unethical procedure in textile industry's supply chain. Children are forced to work, often against their will. In extreme cases, children don't get paid of the work.

Sexual objectification = An unethical procedure in the textile and fashion industry. Sexual objectification of the industry is seen especially in marketing and advertisement of fashion in form of sexual objectification of female/male body and extreme standards of beauty.

Homeworking = One way of working in the textile industry. Compared to factory workers, home workers tend to have much lower pay and only a part of them have legal status of an employee.

Blockchain = Form of technology, which consists of blocks linked together cryptographically. The advantages of blockchain are for example anonymity and tamper resistance.

Bitcoin = Cryptocurrency, which uses blockchain as the fundamental technology.

Hashing = Mathemathical way of generating value from the given information.

Ledger = Describes one blockchain database e.g. all information in one blockchain.

Block = One part of a blockchain ledger. Includes data entered to the blockchain ledger. One blockchain ledger is formed from multiple blocks including data.

Blockchain address = Everyone using a certain blockchain ledger has unique blockchain address. Blockchain address is associated to all the information inputted to the blocks.

RFID = Radio Frequency Identification. Technology to identify and track objects.

NFC = Near Field Communication. Wireless technology utilizing RFID, and identificating and transfering data.

Sensor technology = A device or module, which measures changes in the environment and transfers the data to other electronic devices.

2 Textile industry's supply chain structure and the ethical issues

There are multiple ethical issues in the fashion industry's supply chains, but for this Thesis focuses on three most significant ones: forced labor, low wages and unsafe working conditions. These three issues are chosen as the most significant due to the amounts of workers affected negatively by the issues, how magnificent the issues are (e.g. are they life threatening) and is blockchain technology able to minimize them.

Figure 1 showcases six of the most significant ethical issues in the textile industry. Each one of these issues have been featured in the media and numerous organizations are working towards minimizing the issues. Environmental issues haven't been discussed in this Thesis, so these ethical issues are related only to people's well-being. This analysis has looked into all of these issues from perspectives of scope, magnitude and blockchain implementation. Regarding the column of the scope of people affected, the numbers are directional as all of the precise numbers include all industries, not only the textile industry. Although, it makes the numbers more comparative as they are all presenting total industry numbers. Even more important factor in the comparison is the magnitude of the problem, as some of the consequences of the issues only slightly violate human rights and others, on their worse, lead to the death of workers.

As presented in the figure, taking in to account all of these factors, the most serious problems are forced labour, too small wages, poor working conditions and child labour. The reason why child labour hasn't been chosen as one of the issues presented in this Thesis, is the complexity of the problem. Child labour in developed countries is

unprecedented, but in many developing countries it is considered as one of the income sources for families and in many ways much more standard procedure compared to developed countries. Blockchain utilization in supply chains rely on transparency, and especially bringing transparency to consumers. Many western consumers don't have the capability to handle the complexity of child labour, and that is why there should be other ways to cope with that issue than blockchain.

	People affected negatively	Magnitude of the problem*	Will blockchain implementation help the situation?	Is blockchain possible to implement?
Forced labour	Estimate, 18.7m people[1]	3	Yes	Yes
Too small wages	Nearly all garment workers	3	Yes	Yes
Poor working conditions	Nearly all garment workers in some level	3	Yes	Yes
Child labour	Estimate, 168m childs[2]	3	In some way*	Yes
Sexual objectification*	Nearly all consumers	1	No	No
Homeworking	Tens of millions people[3]	2	Yes	Yes

*Sexual objectification, especially of women, happens mainly through advertising of the industry

*How many factors the problem involves: 1) Violating basic human rights, 2) Endangering human life/workers to significant accidents, 3) Making it impossible for the family to reach next economical level, 4) Creating fear and stress in the working environment

1)(International Labour Organization, 2012), This is an estimation of all people experiencing forced labour in the world.

2) (International Labour Organization, 2015), This is an estimation of all child labour workers in the world.

3) (Kilbourne, 2013), This is an estimation of all people in the world who are working from their homes. Large part of these workers are working in the textile industry.

Figure 1 – Data chart of ethical issues in textile industry's supply chain and magnitude of those issues

2.1 The supply chain management in textile industry

A large geographical distance and a complex structure has made textile industry's supply chain one of the most difficult ones to manage (Agrawal et al., 2018). The supply chain process of a garment starts from the raw material, the tier 4 suppliers. These suppliers

are either raw material farmers or manufacturers, depending is the raw material organic or synthetic. These tier 4 suppliers sell their raw material to spinning mills, tier 3 suppliers, who spin the raw material into yarn. From spinning, the yarn is transferred to weaving or knitting mills, tier 2 suppliers, who weave the yarn into fabric. The fabric is either dyed, printed and finished at the same factory, or it is transferred to another tier 2 supplier where the fabric is finished. The fabric is sold to the garment manufacturer (tier 1 supplier), who finalizes the garment before shipping it for the brand. (Chen *et al.*, 2018) This process is pictured in the Figure 2.

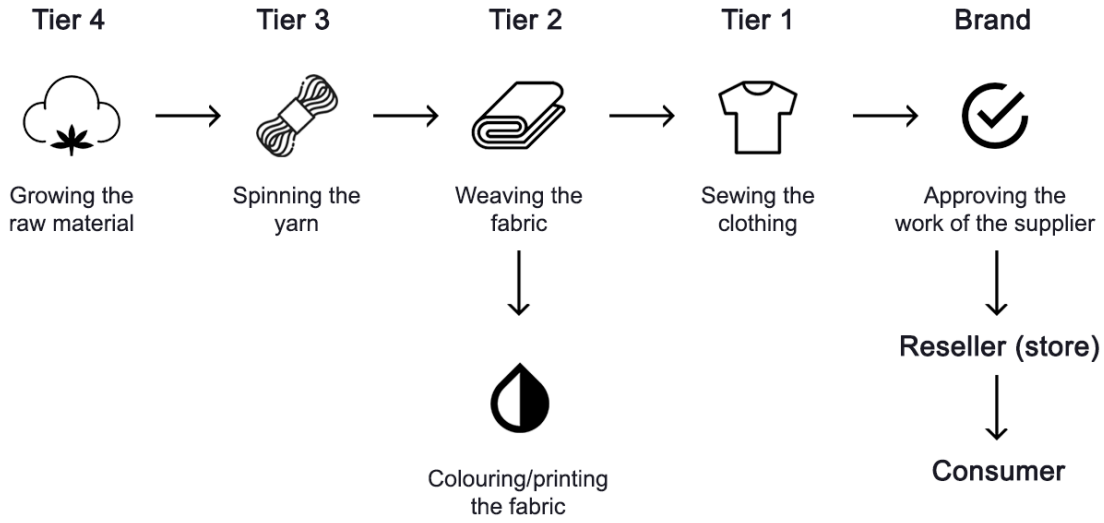

Figure 2 – The supply chain process of textile industry

Multiple-phased supply chains bring especially the lowest tier suppliers to an unfair arrangement as they are rarely involved in negotiations or agreements. In most textile industry companies, the agreement is made between the brand and the Tier 1 supplier. The Tier 1 supplier then makes an agreement with the Tier 2 supplier and so forth. This setting exploits nearly all negotiation power away from lower tier suppliers. This setting is especially brutal when brands are optimizing their cost-efficiency strategy. The low production costs, and this way low wages, are forced by the consumer and brand as a byproduct of achieving low retail prices and cost efficiency. When the cost of a retail price is being reduced, every Tier supplier gets a smaller contribution for their part. Usually this affects the most to the lowest tier suppliers, as the Tier 1 holds the situation for negotiation with the brand. In some cases, brands don't even realize how much these cost-reductions affect the lower tier suppliers.

2.2 Forced labour

Forced labour is seen as one of the manifestations of "modern day" slavery and it still exist in textile industry's supply chain. Characteristic of forced labour are: 1. abuse of power and worker's vulnerability; 2. intimidation and threats; 3. verbal, physical and sexual violence; and 4. restriction of movement and isolation. In case of taking advantage of worker's vulnerability, employer can withhold wages or threat with loss of employment, knowing the worker's poor financial situation. Other threats, as loss of social benefits, threats towards other family members or worse working conditions, are used as well to keep the workers fearful and vulnerable. Verbal, physical and sexual violence is one of the strongest indicators of forced labour. (Persecution *et al.*, 2016) Verbal abuse is still occurring widely in the industry. For example 29,5% of Sri Lanka garment workers reported that they have experienced verbal abuse at the factory they are working at (Hancock *et al.*, 2016). Among verbal abuse, physical and sexual abuse are present in the industry. They do not exist in large scale, but physical violence doesn't need to happen often to have a tremendous fear factor among all workers. Restriction of movement and isolation as a form of forced labour occurs especially in fields (tier 4 suppliers). Workers can be held on the fields for months, not being able to see their family or have decisions on their own movement. (Persecution *et al.*, 2016) One form of restriction of movement is also not giving the worker a possibility to end the working contract and move away from the specific area. This occurs when an employer holds the worker's passport and makes them reliable of the employer (McGuire and Laaser, 2018).

An extreme example of forced labour is Uzbekistan's cotton industry, which is one of the largest one's using forced labour in the textile industry's supply chains. Approximately one million people are forced to plant and harvest cotton from the act of government in Uzbekistan's cotton farms. Regarding this act, the Uzbekistan government gains approximately $1 billion in revenue each year from the sales of cotton. (Persecution *et al.*, 2016) Even that over 300 brands have signed an agreement (Uzbek Cotton Pledge) to prevent the use of forced and child labour in their supply chain, this agreement only states that the brands don't intentionally use cotton produced by forced labour, such as Uzbekistan cotton. As the cotton producer is the tier 4 supplier in brand's supply chain, it is usually impossible to be certainly sure, that cotton produced with forced labour isn't used as a raw material. The only way to guarantee this, is to have direct relations and agreements with the Tier 4 supplier as well, and very few textile industry brands have this.

2.3 Wage issue

Through-out the textile industry's supply chain, most of the workers are paid the minimum wage in the country. The problem arises from the fact, that the minimum wage defined by the government isn't actually a living wage. By the definition of living wage, the wage should cover the worker's and the family's living, food, health and education expenses. With minimum wage, a family is not able to invest in all of these expenses, and often the cuts are made for example in the education of children. Lack of education keeps the children in the same economical stage, and in long term slows down the development of developing countries.

Most of the fast fashion brands clothes are being produced in Asian countries, very often in countries with lowest minimum wages, like Cambodia, Sri Lanka and Bangladesh. In Sri Lanka and Bangladesh, the legal minimum wage covers only 19% of the actual living wage in the country. Textile production in Asia has received a lot of attention due to large factory catastrophes and union workers working hard to better the working conditions. A surprising factor is that in many low-wage European countries the minimum wage is on a lower level percentually from a living wage compared to low-wage Asian countries. Romania, Georgia, Bulgaria, Macedonia, Moldova and Ukraine all fall below the three Asian countries which pay the lowest minimum wage. (McMullen and Musiolek, 2015)

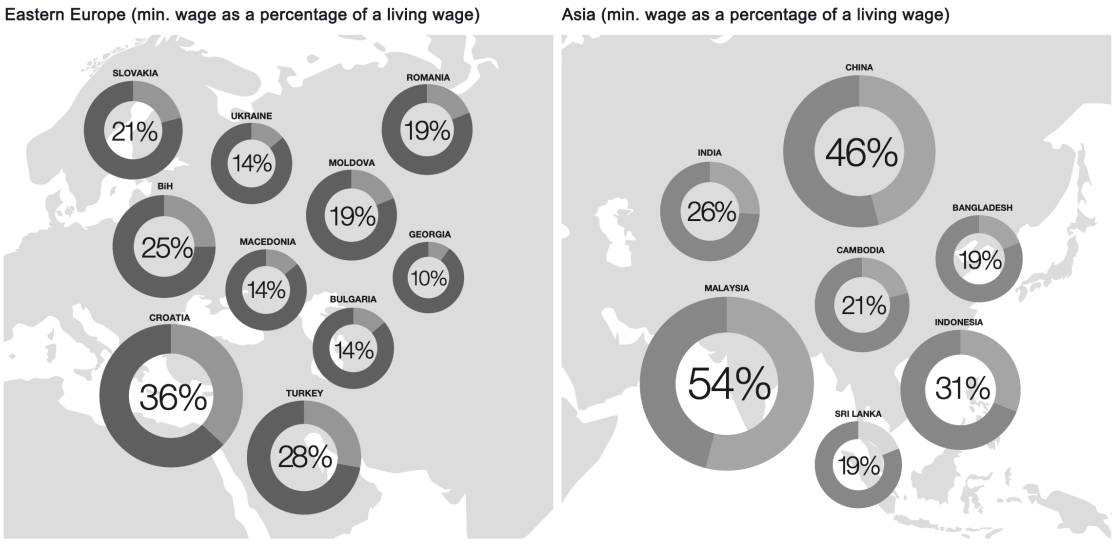

Figure 3 – Minimum wages as a percentage of a living wage in Europe and Asia (McMullen and Musiolek, 2015)

While a garment factory worker (Tier 1 supplier) earns, depending on the country, around 100-200 USD per month, which rarely is a living wage; spinning mill workers

(Tier 3) or cotton farm pickers (Tier 4) earn only from 20 to 60 USD per month. (Stotz and Kane, 2015) This highlights, that the situation with Tier 1 supplier workers is bad, but it is even worse in other tiers.

In 2018 72% of consumers agreed that companies should declare whether they are paying their supply chain workers a living wage (Fashion Revolution, 2018). Many brands have stated their efforts towards living wages and for example H&M, Inditex, Asos and Bestseller have taken a part in ACT-movement, which works actively towards living wage payments for garment workers (ACT, 2019). The problem, which still remains is the lack of transparency to the consumers. Brands state for the consumers that they are working towards living wages, but don't present the data behind the improvements and current stages. Also, an average consumer can't put the raw data in to perspective regarding what the numbers actually mean for the workers. Another problem in this model, is that the brands are widely focusing only in living wages among garment workers, and not the wages of tier 2 to tier 4 workers.

2.4 Unsafe working conditions

The textile industry's unsafe working conditions are acknowledged by the industry broadly. These unsafe working conditions cover every supplier in the industry, from the tier 4 raw material producer to the tier 1 garment factory worker. In raw material production, most of the dangers for the employees comes from hazardous chemicals used in harvesting the raw materials. In garment factories, the employee's lives are put on risk when working in unsafe and poorly structured buildings.

One of the biggest catastrophes in the history of the industry was the collapse of Rana Plaza factory in Bangladesh in 2013, killing over 1,100 and injuring over 2,500 factory employees. The collapse was due to poor structure of the building, which wasn't initially intended to support garment factory machines. Although, the condition of the building was pointed out by the garment workers, the supervisors didn't take any actions towards repairing or closing down the factory. This also violated human rights of the workers and highlighted the longstanding suppression of labor mobilization as worker's didn't have any ability to refuse these working conditions without losing their job. (Comyns and Franklin-Johnson, 2018) The catastrophe of Rana Plaza worked as an eye-opener for many players in the industry, but still a lot remains to be done. Over 200 brands have agreed and signed the ACCORD, an agreement towards a safer textile industry in

Bangladesh, and over 1,500 Bangladesh factories have joined the agreement. The problem arising outside of the contract still remains, as many factories use subcontractors, which might not be under the agreement, to handle large orders. (Barrett, Baumann-pauly and Gu, 2018)

3 Blockchain/smart contract technology

3.1 Underlying theory of blockchain technology

Blockchain technology's origins date back decades ago, but its recent popularity was gained through introduction of bitcoin in 2008. The blockchain technology of bitcoin is a decentralized and peer-validated ledger, which is time-stamped and registers all transactions in chronological order. All individuals in the chain are able to access the ledger and see the transactions. All transactions are validated by the peer-network and sealed cryptographically. (Aste, Tasca and Di Matteo, 2017)

Blockchain technology relies on five fundamental principles to work. 1) The blockchain database is distributed to each party involved in the chain. There is not only one party controlling and submitting the data, but all counterparts can view the input data and all of its history. 2) The communication between counterparts doesn't happen via central node, but instead strictly through peer-to-peer communication. 3) Every blockchain user has over 30 alphanumeric characters in their address, which defines them. This makes blockchain technology fully transparent but gives the opportunity for users to stay anonymous in case needed. All transactions happen via addresses, not personal information. 4) Tampering information is eliminated from blockchain transactions as when information is added to the database, it can't be changed afterwards. All the information submitted to one chain, is connected to the previously submitted information. 5) Blockchain transactions can be connected to computational logic. This allows users to program rules, which automatically create transactions between the chains. (Lansiti M. and Lakhani R. K., 2017)

Anonymity and security are one of the biggest strengths of blockchain technology. The technology is highly secure and the information in the chains is almost impossible to tamper. Every block of information is connected to the previous block, and this provides anyone with an access to the chain to view a reconciled version of the information and

the entire transaction history of the ledger. The information and authenticity of every block is screened by independent blockchain miners. These miners record all valid transactions and transform them into cryptographically sealed blocks, which are then linked to previous blocks through hashing. This process makes the tampering of information extremely difficult, as these individuals would need to control majority of the miners. (Aste, Tasca and Di Matteo, 2017) Also, in case a hacker would like to hack into a certain block of information, they would need to hack into every single block before this certain block. (Min, 2019)

After the introduction of bitcoin, blockchain has also become widely known and researched in other fields outside of financials. The blockchain technology has brought new possibilities for various businesses with value-adding direct transfer of data, replacing the use of a centralized systems with decentralized ones (Aste, Tasca and Di Matteo, 2017). The blockchain is speculated to become even more valuable in other economic and social transactions outside of cryptocurrencies, such as digital asset ownership record. The global economic structure depends on records and resources, such as the data held by financial, education and medical institutions. Often the data of these institutions is maintained by third-parties and this way becomes exposed and extremely vulnerable to corruption and human mistakes. These both could be entirely eliminated with blockchain technology, which is in its core tamper-resistant, incorruptible and un-biased. (Beck *et al.*, 2017).

3.2 Anonymity of blockchain transactions

Users of certain blockchain ledger are able to decide do they want to stay anonymous or reveal their identity (Lansiti M. and Lakhani R. K., 2017). All transactions and activity happens through blockchain addresses, and the users can create as many addresses as they want for different transactions (Pieters and Davarynejad, 2015).

Especially in currency development, anonymity is speculated to be one of the biggest factors accelerating the use of blockchain (Pieters and Davarynejad, 2015). In cryptocurrencies anonymity brings significant confidentiality also for enterprises, not only for individuals. Without cautious actions, the enterprise's sensitive financial details could be revealed. (Ratner, Ré and Bailis, 2018)

Anonymity is one of the fundamental principles of blockchain technology, but newest research papers have identified a lack of security in it. Although users perform transactions with blockchain addresses, these addresses can be clustered and linked to each other, and eventually, used to identify users. With this practice, authors witnessed that 40% of blockchain profiles can be unveiled. (Pieters and Davarynejad, 2015) The industry has started to develope solutions to better anonymity and security in the field of blockchain. One of these solutions is Zerocash, which presents an alternative cryptocurrency using cryptography to exclude all information from the transaction except the actual existence of the transaction. (Ratner, Ré and Bailis, 2018) Anonymity could be the defining factor in the use of blockchain in textile industry's supply chains; textile workers would be able to input information about their living conditions anonymously. This would minimize the possibility of worker's being punished by their supervisors for inputting information about factory conditions.

3.3 Blockchain utilization in supply chains

In a survey by Infosys Consulting in 2017, 62% of professional working in supply chain management didn't know how to utilize blockchain in their work nor how it will affect the industry. Blockchain technology can help reduce organizational and network risks, better the managerial aspects, save time and money in various processes, ease the process of contracting and bring visibility as well as traceability to the supply chain. (Min, 2019)

Contract formation is one of the first steps in supply chains. With smart contracts, which utilize blockchain, the execution of contract agreements can be automatized. Smart contract is a computer protocol which enforces the agreements made to computer system and then automates the execution and tracks the fulfillment of contract agreements. Smart contracts can reduce risks, improve the obeying of rules and increase efficiency. (Min, 2019) Largest and most popular smart contract platform today is Ethereum.

Asset tracking with blockchain presents two gains for the supply chain management. Once the ownership of tangible or intangible assets is inputted to the ledger, it can't be changed without the permission of the owner of the block, as the history of blocks can't be tampered and changed. (Min, 2019) This brings security to the supply chain management, especially in case there is no face to face contact with the suppliers, or the management/contact persons change. In addition, asset tracking makes it tremendously easier to prevent counterfeits and track the product all the way through its supply chain.

This tracking makes it easier for the company to understand their bottle necks which can be then eliminated, product costs which could be reduced, and unethical actions, which can be eventually eliminated.

In addition to these more security-adding activities, blockchain can have a major improvement in cost-efficiency and management aspects. Removal of third-party involvement with blockchain, will equal to reduced transactions costs and reduction of used time in supply chain actions. With blockchain it is fairly easy to better visibility among the company and different departments/employees. (Min, 2019) In many companies this lack of visibility is unintentional due to the amount of parties involved and complexity of processes. With blockchain, the employees involved in the project are automatically included in all information from the first touch point onwards.

4 Results: blockchain technology on solving ethical issues in textile industry's supply chain

Based on the facts presented in previous chapters, blockchain technology is able to make the textile industy's supply chain increasingly transparent for the brand itself, but most importantly for the end-customers. Without the blockchain technology, textile industry's supply chain is very linear, as stated in the Figure 2. In Figure 4 I've presented the chain with the implementation of blockchain, when it becomes more coherent and shared through out the process. The most significant change is the possibility for all counterparts of the chain to be able to see all information in real time and afterwards. This means, that for example the brand is able to see in real time what is happening in each of the factory, and take actions in case something is done wrong, but also the consumer is able to see the whole process retroactively. Transparency of the supply chain will also educate consumers to better understand the textile industry and its functions.

Smart contract, a specific form of blockchain, can add additional value to the "normal blockchain ledger". Smart contracts can't be directly used to help consumers understand the provenance of the products, but they can be used to ease and automate the work load of brands. Smart contracts can be implemented to make the tracking of supplier actions automatic. This excludes the need for the brands to manually check that every supplier is working by ethical rules.

In addition to blockchain implementation, there are also other technologies that can enhance the supply chain transparency. Most of these technologies gain the most advantage when used in comparison with the blockchain technology. These are for example sensor and RFID technology, which will be covered more precisely in the next chapter.

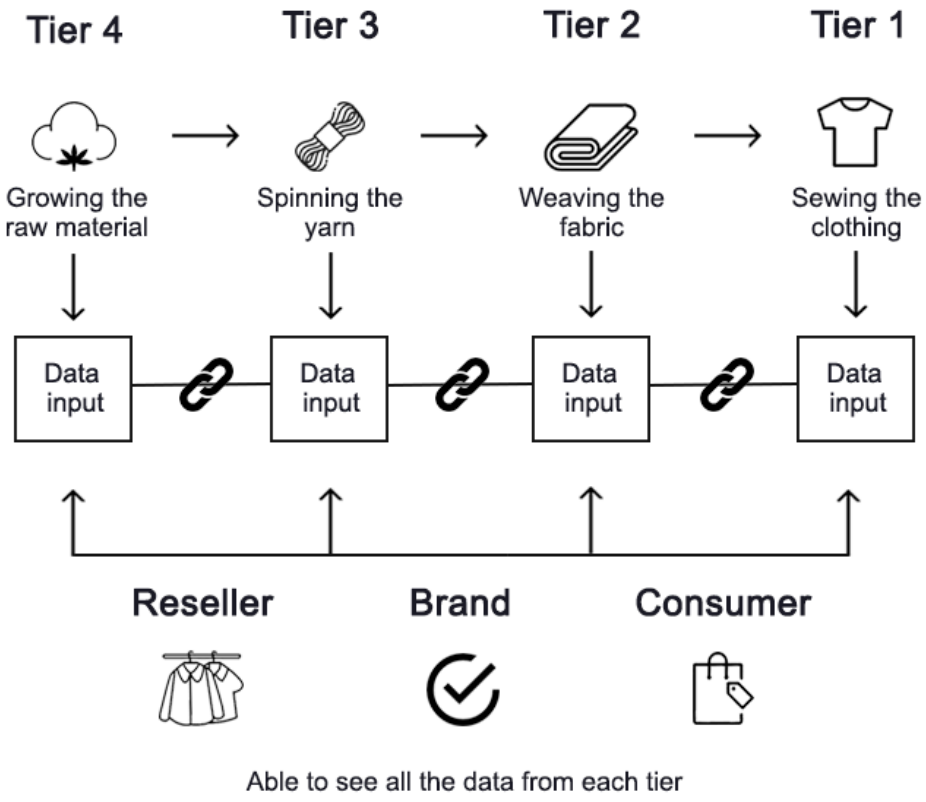

Figure 4 – Textile industry supply chain structure after the implementation of blockchain

4.1 Blockchain technology on three fundamental ethical issues in the textile industry's supply chain

Regarding forced labour, and especially extreme cases of forced labour, as for example the Uzbekistan cotton industry, blockchain technology can provide clear solution in choosing suppliers. With blockchain ledgers, the origin of products can be documented, and brands have the possibility to boycott certain areas entirely from their supply chain. In other cases of forced labour, blockchain technology could be implemented as a ledger, to which all employees would have an access. This would give a possibility for the workers to state if they have experienced abuse, received their wages according to the agreement or been blackmailed during their employment. As one of the blockchain's principles is

anonymity, workers would be able to input this data without their supervisors being aware of the fact who has stated this information. This model is elaborated more in the Figure 5.

Most developing countries have government-set minimum wage, or it is set by the industry with bargaining agreements. As stated earlier, the problem is not, that suppliers wouldn't pay the minimum wage for their workers, but that the minimum wage doesn't equal as a living wage. With blockchain technology, all wages paid by the supplier can be tracked and then compared to the living wages of the country. From the perspective of brands, they can ensure a transparent supply chain by choosing only suppliers who use blockchain technology.

Another way to utilize blockchain technology in terms of wages is, as in case of forced labour, to permit access to the ledger for the workers. This additionally supports the entire supply chain, as workers from each tier are able to input the data of their wages. In practice the blockchain formation would start with the raw material producer, who seils the data of their wages to the first block. While the raw material producer ships the actual raw material to the spinning mill owner (Tier 3), they can transfer the blockchain ledger to the tier 3 workers. In this scenario, the managers of the factories would not even need to be granted an access to the blockchain ledger. Instead, the entire ledger could be managed by labour right organizations or other similar, local entities, and the workers would be the ones having ability to entry data to the ledger.

Regarding working conditions, blockchain can be implemented in a similar way as stated previously, or more effectively and automatically with sensor technology. Sensors, connected to blockchain technology, can automatically input data to the blockchain ledger (Caro *et al.*, 2018). This would exclude the possibility to un-truthful data input and automate the data input process. As stated previously, the most hazardous and significant danger towards workers comes from unstable factory buildings with the danger of collapse (usually Tier 1-3 suppliers) and toxic pestisides used in growing the raw materials (usually Tier 4 suppliers). Sensors tracking the building structure, fire alarm operation and the accessibility of emergency exits could transfer the realtime data to the blockchain database and notificate in case of breach. Sensoring the raw material composition or the field's soil could tell has there been used toxic pestisides in the growth process.

Today numerous suppliers have certifications to support and confirm their actions, for example on safe building structures or payment of living wages. These certifications offer a fundament and guidelines for ethical actions, but don't make the supply chain entirely transparent. The same problems occur with certificate institutions, as do with brands: actions are difficult to track in every tier, there might be trust issues regarding the information given by the supplier and even the Tier 1 supplier themselves can't guarantee ethical actions throughout their supply chain. Blockchain technology presents as big of an opportunity for certificate institutions as it does for textile/fashion companies themselves. In case every certificate would focus just on a specific problem and making this transparent in every supply chain, companies could implement all of these certificates to their supply chains and would not need to worry about each problem separately.

4.2 Illustrative case: Provenance, utilizing blockchain technology for supply chain transparency

Provenance is an UK-based for-profit startup developing a blockchain solution to increase transparency of supply chains and create traceable products. The startup was founded in 2014 by Jessi Baker, and has raised over $1 million in funding till today (Crunchbase, 2019). Alongside the creation of a blockchain technology, Provenance offers consulting, content creation and system design for companies wanting to increase their transparency (Project Provenance Ltd, 2019). This case presentation will only focus on the blockchain technology Provenance is building, how it is structured and how different stakeholders are linked to the platform. The case example has been chosen for this Thesis because Provenance has textile industry customers, who have utilized their technology. Provenance presents a clear example of the use of blockchain technology in the textile industry. A white paper written by Provenance team in 2015 has been used as the base for the case presentation.

There are six different stakeholders involved in the set-up of Provenance: 1) Producers *(tier 4 supplier),* 2) Manufacturers *(tier 1-3 suppliers),* 3) Registrars *(authorities and organisations providing credentials),* 4) Organisations defining legislations *(e.g. Fairtrade),* 5) Auditors *(inspectors of manufacturers and producers),* and 5) Customers *(including brands and end-customers).* The principal architecture of Provenance consists of different programs which can be linked together, tagging between digital and physical world, and user-friendly interface for the customer. (Project Provenance Ltd, 2015)

The trust relationship is formed via registration program, to which all users of the blockchain ledger register. This program creates a digital identity for every counterpart, and they can decide to continue using anonymous ID or link the account to their real-world identity. In case of using anonymous IDs, only the certifiers are able to view and verify the real identity. (Project Provenance Ltd, 2015) In case of textile industry workers entering information to the blockchain ledger, they could stay anonymous and the certifiers could verify their identity. This relates back to the conclusion addressed in chapter 5.1. In case the workers would enter the data in to the ledger instead of the tier managers, false information could be minimized from the system. The tier managers have motive to enter un-trutful information to the ledger to present their factory in good light and gain financial and organizational benefits. In case the workers are able to do the data input anonymously, they don't have any motive to enter false information to the ledger. This possible model is presented more in detail below in Figure 5. In this figure, tier managers are only able to view to blockchain data. They could also have a possibility to enter their own data, as there is no possibility for them to alter the data inputted by the workers. The managers are able to view the data inputted by the workers, but they can't link this to a specific worker and this way can't punish them.

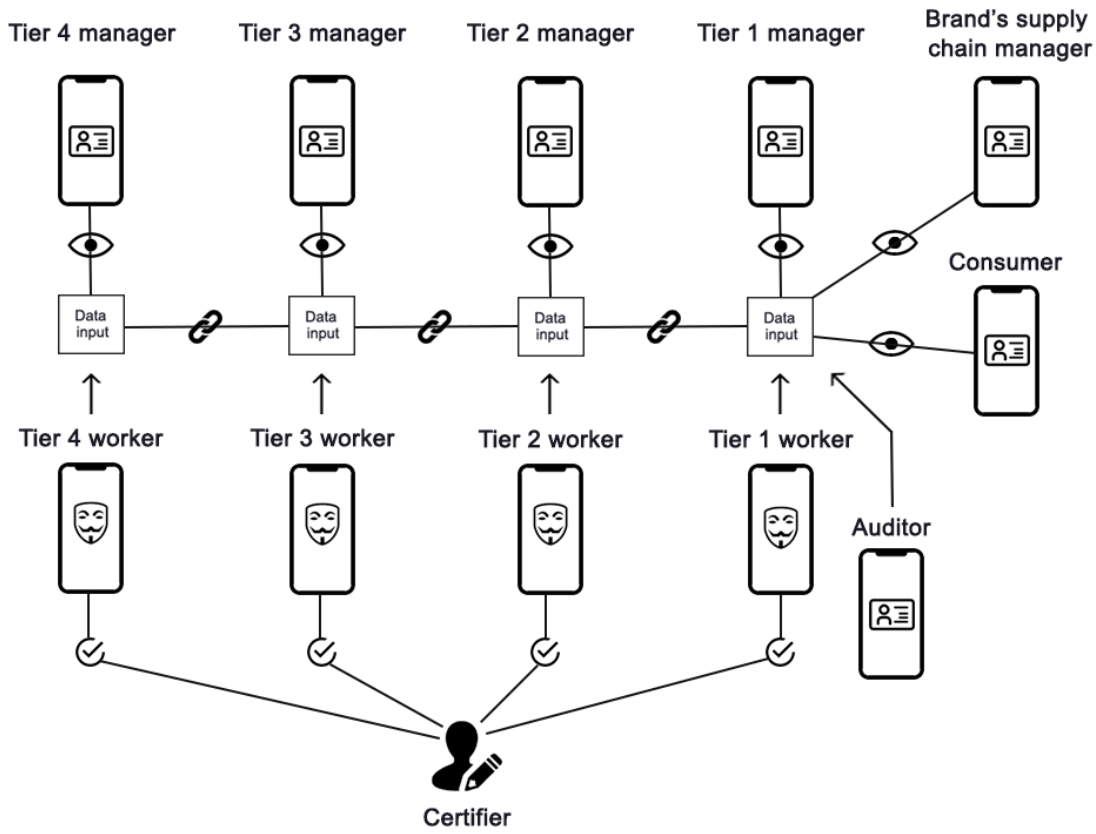

Figure 5 – Blockchain structure with workers entering the data to the blocks

As one of the programs, Provenance has presented a system to verify and assign sustainable certifications and standards, e.g. fair trade, no animal testing and fair labour. This prototype tracks four different components throughout the supply chain: features, quality, quantity and ownership. The organisations present the parameters used to certificate the products, and the program audits the implementation of these in each stage. If unsuccessfull audit is detected, the program can be temporarily revoked. (Project Provenance Ltd, 2015) Unlike in the previous example, where anonymity could be the key factor, in this program the producer expresses the fundamental base for the traceability and there is trust provided also for the producer. In Figure 6 this process is explained more precisely. In this example, all audits have been successful, in case of unsuccessful audit the program could be revoked as soon as the information which doesn't match the requirements is detected. As discussed in the last chapter, this form of blockchain usage could bring major easements to companies in terms of financial and people resources, as different certifiers would track different parts of the supply chain. This example presented in Figure 6 could for example track only the wages of the workers.

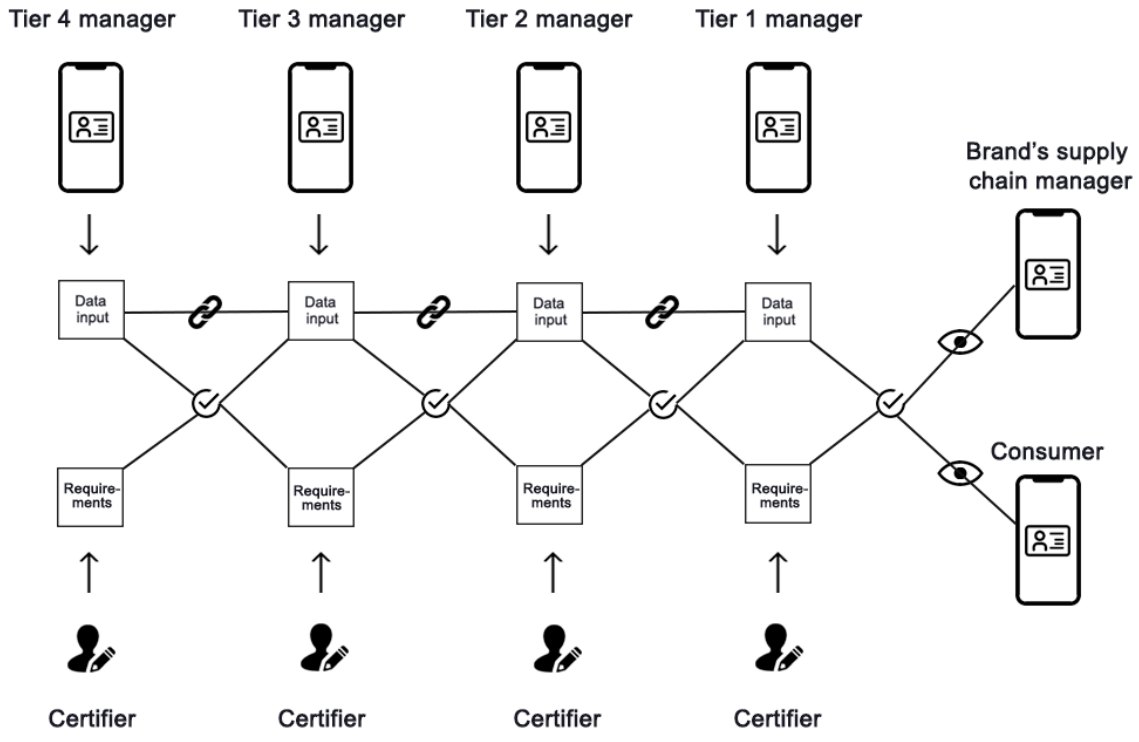

Figure 6 – Blockchain structure with certifier requirements and tier managers inputting the data

When the information has been successfully tracked to blockchain ledgers, there needs to be secure linking between physical product and the right digital counterpart.

Provenance has explored multiple different identification technologies, e.g. bar codes, RFID, NFC and genetic tags. These tags and serial numbers are then linked to blockchain ledgers with secure hashes. This information is then made available for consumer via bar codes or QR-codes, which are scannable via smartphones. (Project Provenance Ltd, 2015)

Throughout the whole process, Provenance utilizes the public-private key infrastructure in their technology. This allows them to mimic physical signatures in all agreements and confirmations in the ledgers. Participants in the ledger use their private key in all actions in the ledger. The actions and the identity of the user (anonymous ID or more in detail identity) are visible to other participants, but the private key is never visible to anyone. This allows other participants to confirm that the information/document was published by this very user. (Project Provenance Ltd, 2015)

4.3 The disadvantages and difficulties of the blockchain technology

Blockchain is still relatively new technology, and the implementation of the technology is still in state of prototypes and testing in various fields. Alongside this, there are also difficulties and problems in utilizing the technology.

One of the very obvious problems in blockchain relates to capacity of the technology. As the use of technology is growing, the capacity and power of it should be continuously bettered. At the moment blockhain can conduct only seven transaction per second, while VISA is able to conduct 47,000 in the same time. This factor is largely due to the restricted size of the blocks. Another problem related to the growing use of blockchain, is the increasing need for storage and synchronization. (Caro *et al.*, 2018)

Even that the fundamental reason for using blockchain relies on making processes more transparent, trackable and auditable, there is a chance for corruption and false information in the data input. This problem is extremely cautious especially when blockchain is used in supply chains. The ledger itself won't prevent the user to entry false information to the chain, and when the information is in the ledger it is impossible to be altered or removed (O'Connor, 2019). Possibility to enter false information presents an opportunity also for corruption between higher and lower tier suppliers. In case the information is inputted to the ledger manually, and not for example automatically audited from sensors, higher tier suppliers are in a position to force lower tier suppliers to enter false, "more preferable" information to the ledger. One way to minimize this

problem would be to allow all employees use the blockchain ledger and see the information inputs, then in case of false input they could be in contact with auditors or other organisations involved in the process. Also contracts with serious consequences could be a way to minimize these actions. A way to entirely remove the possibility for false information is to enter information through sensor/RFID technology, which audits the data input automatically. The use of sensor technology was explored more broadly in the section 5.1.

In addition to these difficulties, the implementation of blockchain technology requires, like any new technology implementation, an increased amount of working hours from employees and significant financial investments. The blockchain technology implementation will also require the workers and managers in all tiers to learn to use the system and dedicate time daily to audit and report their procedures.

5 Discussions and conclusion

5.1 Implications to practice

Based on the research of Fashion Revolution in 2018, 70 out of 200 major fashion companies released their Tier 1 supplier list. These brands would be ideal to utilize the blockchain technology to bring transparency also for their other tier relations. Many of these companies are using their transparent actions as a competitive advantage in their market, so they would have incentive to improve this advantage with blockchain.

Let's elaborate through an example of the current actions these consciously aware companies are performing, and how blockchain could make a significant change in the actions. H&M is one of the biggest fast fashion companies and it is also one of the companies who has released their Tier 1 supplier list. H&M has been actively working towards more transparent supply chains, but even in their sustainability actions listing, there is no mention about the utilization of blockchain. H&M group has in recent years even founded an entirely new brand, Arket, with core focus to transparency and ethical supply chains. Consumers can find supplier list on the Arket website, but the way the information is presented leaves major caps to the information received by the consumer. For example, one of their cotton shirts is told being produced by "Esquel" supplier in Hong Kong. The inheritage and procedures of this supplier are being presented at the website. When looking more precisely into the manufacturing details, we can find that

the shirt is actually produced in China, in factory called Yang Mei. From this information we can assume that this precise factory might be Esquel's subcontractor, and we don't have any guaranteed information about the working conditions, wage payment or other ethical perspectives of the factory. This example emphasizes the difficulty of tracking and showcasing the supply chain information, even in case the brand itself wants to be more transparent. With blockchain, this information would be transfered automatically with the garment to the consumer, and there would not be a necessity to make assumptions from the consumer perspective.

In addition to the clear advantage presented for the companies, numerous organizations and certificate providers are able to benefit from the technology, as elaborated in the previous chapter. The main benefits in this sector are the cost-efficiency and savings in human resources in the logn term. Most of the organisations improving supply chain conditions work as non-profits and rely mostly on volunteer activities and on goodwill. Blockchain technology could help these organizations to make more significant changes in the industry with less human resources and financial investments.

5.2 Limitations and future research

The main limitations for this Thesis paper were the limited time frame the research was conducted in, lack of previous in-depth understanding of the subject and the lack of real data from actual textile industry supply chain limitations and working procedures. With longer timeframe, the subject could be addressed in more depth, and especially the technical functions of blockchain could be elaborated more broadly. Before starting the research, I had some understanding of the textile industry's supply chain structure and the ethical challenges. In case the understanding would have been broader to begin with, the ethicality of the issues could have been researched even more deeper level. The lack of real data about the textile industry's supply chains restricted the research to editorialise on the perspective how blockchain technology will change the structure of the supply chains. In case a broader dataset would be available, implementation of blockchain technology could be researched from perspective of affects on supply chain relationships, lead times, cost structure and delivery times etc. This would be ideal future research topic regarding the subject.

Regarding more on the future research, there is a lot potential on different fields. One of the major questions in regarding this topis is how to exclude, not only minimize, the false information from the blockchain ledgers completety. This was touched upon in this

Thesis briefly, and more from the perspective of minimizing. When implementating blockchain technology to real-life supply chains, this presents a major difficulty for brands.

Looking more from the perspective of the technology itself, the future research should focus on how to handle and improve the capacity of the blockchain to respond the needs of even the most complicated and information-heavy supply chains. This difficulty brings a major challenge to the implementation, because with out the increasement in the capacity, the implementation of the technology is impossible to introduce.

Interesting perspective for future research is also consumer perception about the subject. In case the blockchain technology is implemented, one of the key reasons is to bring more transparency especially to consumers. It is important to research how consumers perceive the technology usage and how it would affect their behavior.

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