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Digitalization in logistics for textiles – possible fields of application for the Blockchain technology

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ABSTRACT

The globalized supply chains of textiles and clothes involve multiple parties from different countries. Flows of goods, information and finances are coordinated through logistic processes, but offer potential for optimization in terms of digitalization and transparency. Incidents of the past prove that fundamental human rights standards and occupational safety are not met in global production countries yet. Legal regulations like the Act on Corporate Due Diligence Obligations for the Prevention of Human Rights Violations in Supply Chains (LkSG) shall help to improve the situation since 2023. Especially small and medium sized enterprises (SME) in Germany, to which the law applies indirectly through private-sector contracts from their non-SME consignees, struggle to control their global supply chain, to provide all necessary data and to ensure a traceable, fraud-resistant and manageable flow of information. Hence, the Center Textile Logistics investigated the potential of the Blockchain technology and its application possibilities for textile supply chains. The Blockchain technology offer chances in terms of securing clothing trademarks, proofing that standards of seals and certificates are met, proofing that political and legal regulations are met and in terms of controlling global processes that involve international suppliers and partners. However, the current state of the art of digitalization is often too low to directly apply the Blockchain technology and has to be improved first. The cost-benefit ratio has to be evaluated individually but the Blockchain technology offers great potential to rise transparency, ease communication and critical data exchange along textile supply chains.

1 Introduction

On November 15th, 2022, the global population has exceeded eight billion people for the first time [1]. The growth of the worldwide population goes along with an increasing demand for resources which are often finite. Human beings of the Western World follow a high standard of living at the expense of less developed countries and future generations. Once a year, the organization Global Footprint Network calculates the Earth Overshoot Day. “A country’s overshoot day is the date on which Earth Overshoot Day would fall if all of humanity consumed like the people in that country.” [2] It indicates the use of biological capacities by human beings as well as the planet’s ability for regeneration and the effects of human action. In Germany the Overshoot Day is calculated for May 4th 2023, which means from this day on the demand for ecological resources and services exceeds the earth’s regeneration capacities in 2023.

One precise example for increasing consumption is the demand for textiles and clothes in Germany. Each year German citizens buy between 12 and 15 kilograms of clothes per person which is above the global average of eight kilograms. The demand is expected to increase further by 2030 [3]. Due to decreasing qualities of clothes and the trend of (ultra-)fast fashion, the useful lifecycle time of products decreases while the consumption increases. The manufacturing of clothes is characterized by globalized supply chains because of a high share of manual labor during the production process and an outsourcing of these processes to low-cost countries, for example to countries in Asia. According to the German Environment Agency (Umweltbundesamt), about 90% of the clothes that are bought in Germany origin from production countries like China, Turkey or Bangladesh [4]. The focus of production in Germany is on technical textiles which are used in the automotive industry, the construction industry or in medical applications. In 2021, 61% of all fibers produced in Germany were applied as technical textiles, 26% were utilized for home textiles and 13% were capitalized for clothes [5].

The textile and clothing industry contributes to the global exploitation of resources to a high share. Due to the journal EU Recycling, the European consumption of textiles is one of the main reasons for environmental pollution and is jointly responsible for climate change. In Germany about 1.3 million tons of used clothes and shoes are collected annually which amounts to more than 15 kilograms per citizen with upward trend [6]. A further challenge for the industry is that fundamental human rights standards and occupational safety are not always met in global production countries, as incidents of the pasts such as the collapse of the production plant Rana Plaza in Bangladesh in 2013 or the fires of the factory Ali Enterprise in Karachi in Pakistan in 2012 have shown. Legal regulations in Germany like the Act on Corporate Due Diligence Obligations for the Prevention of Human Rights Violations in Supply Chains (Lieferkettensorgfaltspflichtengesetz, LkSG) intend to contribute to an improvement in the overall conditions from 2023 onward. Also the EU strategy for sustainable and circular textiles aims at shaping the industry towards more sustainability and environmental friendliness. Moreover the textile and clothing industry increasingly has to deal with the effects of white-collar crime like product piracy. In 2020 clothes and accessories belonged to the top five most-effected product categories of about 66 million counterfeited articles which were embargoed in the European domestic market [7].

Due to frequent seasonal changes, a high import rate and high rate of returns in fashion e-commerce, logistics play an important role in the textile and clothing industry. They comprise flows of goods, finances and information and connect the production countries with the market for sales and distribution. However, for companies in Germany, especially small and medium sized ones, to whom the LkSG applies, it requires a considerable effort to control their global supply chain and the companies involved, to provide all the necessary data and to ensure a traceable, fraud-proof and controllable flow of information. A 2022 international survey by Sapio Research proved that 60% of the interviewed companies with more than 1.000 employees are not able to evaluate whether their first tier suppliers meet the demanded standards in terms of environment, social aspects and corporate governance. Most interviewees stated a missing exchange of data as main obstacle that prevents them to meet the claimed obligations. Digital technologies may help to optimize flows of information, processes and resource efficiency. The Blockchain technology is known for protection against manipulation, sovereignty,

traceability and transparency of stored data. It provides support in terms of developing flows of trust-intensive information, flows of data that require verification and the exchange of confidential legal data.

Hence, the research cooperation Centre Textile Logistics investigated the potential of the Blockchain technology and its application possibilities for textile supply chains within the scope of a study of the serial publication “Blockchain Navigator”. It revealed that the advantages of the Blockchain technology offer opportunities in terms of securing clothing trademarks, proofing that standards of seals and certificates are met, proofing that political and legal regulations like the LkSG are met and in terms of controlling global processes that involve international suppliers and partners. However, the current state of the art of digitalization is often too low to directly apply the Blockchain technology and has to be improved first. The cost-benefit ratio must be evaluated individually, but the Blockchain technology offers great potential to enhancing transparency, ease communication and critical data exchange along the textile supply chain.

2 Method

In order to evaluate the practical potential of the Blockchain technology and its application possibilities in the textile and clothing industry the following methodological approach has been chosen. As foundation a fundamental literature research, four guided expert interviews and results of various project works at the Centre Textile Logistics were combined. Afterwards a PESTLE analysis was undertaken to evaluate political, legal, economical, technological, societal and ecological factors that influence the potential use of the Blockchain technology. Furthermore, a SWOT analysis (strengths, weaknesses, threats and opportunities analysis) was conducted to explore the potential of the Blockchain technology combined with the current developments taking place in the textile and clothing industry. Finally, a vision of the future of the Blockchain in textile logistics was portrayed, presenting various use cases as well as its advantages and disadvantages. All results were comprehensively compiled in the study “Digitalization in textile logistics – possible fields of application for the Blockchain technology” [8].

3 Test/Data

3.1 State of the art of digitalization in textile logistics

Current trends and developments in the textile and clothing industry comprise an increasing attention laid on seals and certificates of clothing products, legal regulations like the EU Green Deal, the EU strategy for sustainable and circular textiles or the German Act on Corporate Due Diligence Obligations for the Prevention of Human Rights Violations in Supply Chains. Also reshoring and nearshoring of production facilities closer to the European market, fast fashion and contrary approaches of circular textile chains and the recycling of used clothes increasingly gain relevance. All of the developments reframe the environment of the industry demanding an adoption of business processes and innovative solution approaches along the textile supply chain. Our investigations led to the conclusion that the degree of digitalization of companies in Germany varies according to the size of the enterprise. Small and medium-sized companies usually find it challenging and have not yet digitized all their processes because the investment costs for such a transformation are high. However, the delta of investment in digitalization will grow with delaying the technological progress further on. Large enterprises usually have access to more financial resources and are advanced in terms of digitalization. The German Federal Ministry for Economic Affairs and Climate Action (Bundesministerium für Wirtschaft und Klimaschutz) stated that the digitalization index in Germany did only increase slightly from 2021 to 2022 from 107.9 to 108.9 points. The index is used to evaluate the state of the art of digitalization of the German economy and implies 37 indicators that evaluate the digital degree of maturity of processes or the digital interconnectivity for example [9]. Reasons for the deficit in digitalization contain corporate uncertainty due to the SARS-CoV-2 pandemic, political crisis, high cost pressure because of the inflation and the energy crisis. Initiatives like for example “Medium sized business 4.0 Centre of competences for textiles connects” (Mittelstand 4.0 Kompetenzzentrum Textil vernetzt) are intended to help small and medium sized companies of the textile and clothing industry to improve their digital fitness and offer various possibilities to support the implementation of artificial intelligence. The initiative covers trainings for

employees, the promotion of corporate cooperations, events and inspections of the companies' environment through experts [10]. Textile logistics may benefit from digital technologies in terms of track and tracing applications for increased supply chain visibility or tools to improve risk management by generating event-based warnings along global supply chain networks. The following practical examples offer insights in existing applications of digital technologies in textile logistics.

3.2 Selected practical examples of existing applications of digital technologies in textile logistics

Since 2010 the German clothing manufacturer Gerry Weber has been using RFID (radio-frequency identification) tags for traceability purposes. The RFID chips which are sewn into the clothes contain an individual number of identification and can be scanned by a laser scanner. The individual numbers of identification are saved in a database so each item can be identified. Information about logistical processes like the transport of goods or manufacturer information like care instructions are saved as electronic product code. The use case is partially criticized because it offers Gerry Weber the chance to establish a movement profile of each customer without them knowing [11]. However, the RFID tags offer advantages in terms of a more precise and faster recording of goods, in between inventories and a better control of outgoing goods from warehouses [12].

The cooperation between KiK Textilien und Non-Food GmbH even shows an example of the application of the Blockchain technology in the textile and clothing industry. Based on digital product twins product delivery data, product information and certificates can be exchanged in a digital and transparent manner between various partners of a complex supply chain network. The different partners can realize a safe flow of sensitive data about social or ecological standards via the Blockchain technology without having to integrate an additional platform provider. This helps to improve the efficiency and transparency of global audits of suppliers and manufacturers and offers competitive advantages for the companies using this solution [13].

Retraced is a company that offers a digital solution for an improved traceability of supply chains and an extended transparency of data focusing on fashion and textile companies as potential customers. The platform solution of Retraced shall serve as a sustainability management tool and various partners of a company's supply chain can store data about how products are manufactured or traded. Selected information may also be shared with the end customers [14]. Certificates, used materials, information about the working conditions in the production facilities or information about the environmental influence of a clothing product belong to the information that may be provided. Retraced states that all documents are verified in order to ensure the authenticity of the information. The software solution is based on the use of artificial intelligence and Blockchain [14].

3.3 Influencing factors with potential future impact for the application of the Blockchain technology

The factors that may potentially influence the use of the Blockchain technology in the textile and clothing industry prospectively comprise economical, technological, societal, legal and ecological factors.

Economic developments, such as the inflation in Germany, shape the consumers' shopping behavior as part of the economic factors. As a consequence of an overall rise in the price level, the demand for affordable and cheap products in the product category of clothes has increased over the past couple of months. (Ultra-)fast fashion meets this request and serves as solution for low budgets for clothes. However, the products often go along with decreasing product qualities and lower product lifecycle times. Contrary the interest in sustainable and certified high quality clothes that usually cost more is increasing as well as people become more and more conscious about sustainability in general. The structure of the market is complex and often represents a gap between the communicated shopping behavior of customers and the actual one. Moreover, changes in sales channels have occurred over the past years, as the sales volume in e-commerce increases whereas stationary retailers suffer from decreasing amounts of customers. During the SARS-CoV-2 pandemic this trend has been reinforced due to several lockdowns and no possibility to buy products in local retail stores. Industry experts stated

during the interviews that the clothing market in Germany is characterized by tough competition and severe, partially seasonal, discounts that challenge the companies and demand optimized stocks to save costs. Category management is another burden as the space on sales floors is limited and pricy. Legal changes often result in companies' obligations to document (parts of) their supply chains which creates a need for qualified personnel and financial resources, which is not always available internally and leads to purchasing external expertise. The interviewed industry experts stated that digitalization is only slowly implemented by the companies of the industry and especially small and medium sized ones struggle to do so. A fundamental database has to be established first and data quality has to be improved before the Blockchain technology may help to conquer economic developments that demand optimized and digitalized processes. Therefore, investments and the development of IT expertise are needed first.

In terms of technological factors focus is laid on the degree of digitalization. During the expert interviews it became evident that there is a big difference between small and medium sized companies and large enterprises regarding the degree of digitalization. Small companies often lack financial resources to implement innovative technologies. It is anticipated that missing investments in digitalization will delay their technological progress further on and result in a dwindling spiral and competitive disadvantages. Large enterprises usually have better access to financial resources and are advanced in terms of digitalization. Due to a survey of the German federal association for materials management (Bundesverband Materialwirtschaft, Einkauf und Logistik e. V.) from December 2022 only 7% of German companies have already implemented the Blockchain technology in applications of their daily businesses while 5% are currently testing the Blockchain. 64% of the surveyed companies currently do not plan to test nor implement the Blockchain technology [15]. One may conclude that companies prioritise other technologies than the Blockchain and the organizational as well as technological base has yet to be established first. Primarily, strategies for tracking and tracing and a better supply chain visibility have been the focus of companies in recent years which may also be realized by using the Blockchain technology. Software-tools for risk management and corporate supply chain responsibility have been procured by the companies to meet legal requirements.

Societal factors with a potential future impact for the application of the Blockchain technology in the textile and clothing industry address the conflicting interests of end customers. While some seek fast fashion and follow short-lived fashion trends, others demand certified labels that can verify sustainable global production and compliance with corporate social responsibility standards. Proven sustainability along global supply chains may become a distinguishing feature of the future between the competitors on the market. However, there are currently various seals of quality that are used by clothing manufacturers and lead to confusion among the customers as every seal represents individual standards and varies in the scope of covered proof or field of application. Often clothing labels are accused for greenwashing which leads to the demand of clear and easily understandable proof of standards that may be realized by the help of the Blockchain technology.

The legal framework of the industry is shaped by the adaption of legal requirements and newly set standards in terms of social corporate responsibility. For example, the LkSG in Germany influences the textile and clothing industry as verifications of human rights standards and global suppliers codes of conduct have to be provided. One core element of the LkSG is the establishment of a risk management that controls all involved companies of a supply chain. Another element is the formal obligation of first-tier suppliers to take over responsibility to prevent human rights violations. Furthermore, global incidents like geopolitical conflicts, e.g. the Russian war against Ukraine, influence global supply chains. The Blockchain technology may help to fulfill the requirements resulting from sanctions. This could for example be implemented in accordance to customs regulations or companies' (internal) risk management. Also the European Green Deal or the EU strategy for sustainable and circular textiles set new requirements that have to be respected in global production processes in the near future. Moreover, the EU parliament passed the Corporate Sustainability Due Diligence Directive (CSDDD) on 1st June 2023 that connects the above mentioned legal requirements and applies to all EU-based companies. Consequently, the CSDDD will be transferred to the EU member states' laws in the coming years after further law-finding and implementation stages.

With regard to the ecological environment of the textile and clothing industry, conserving finite resources is focused. The effects of the clothing production on climate change cannot be neglected. For the production of one cotton t-shirt, 2.495 liters of water are needed in average, for example. This eco-balance comprises the irrigation of cotton plantations, the purification of raw cotton as well as further steps of the fabric production including finishing processes [16]. The extended eco-balance, e.g. household laundries of the end consumers, are not encompassed yet. The awareness of end consumers for a more sustainable consumption of products is increasing. Therefore a lot of people search for orientation and look for quality seals and information on clothing products that provide information about resource-efficient and environmental-friendly production. Because there is a variety of seals in the industry covering different standards, confusion arises among consumers, and companies are accused of greenwashing by portraying themselves as more sustainable than they actually are. This situation presents opportunities for the application of the Blockchain technology which can be implemented to provide authentic and validated proofs of sustainably along the textile value chain. For clothing manufacturers and labels this offers the chance to better position themselves on the market and to prevent damages to their images. They may also prevent lawsuits due to a violation of legal standards.

4 Results

4.1 Selected practical examples of existing applications of digital technologies in textile logistics

The sectorial specifications of the textile and clothing industry suggest a high potential for the application of the Blockchain technology in various cases. Figure 1 shows the results of the SWOT analysis conducted to explore the potential of the Blockchain technology in combination with the current developments taking place in the textile and clothing industry

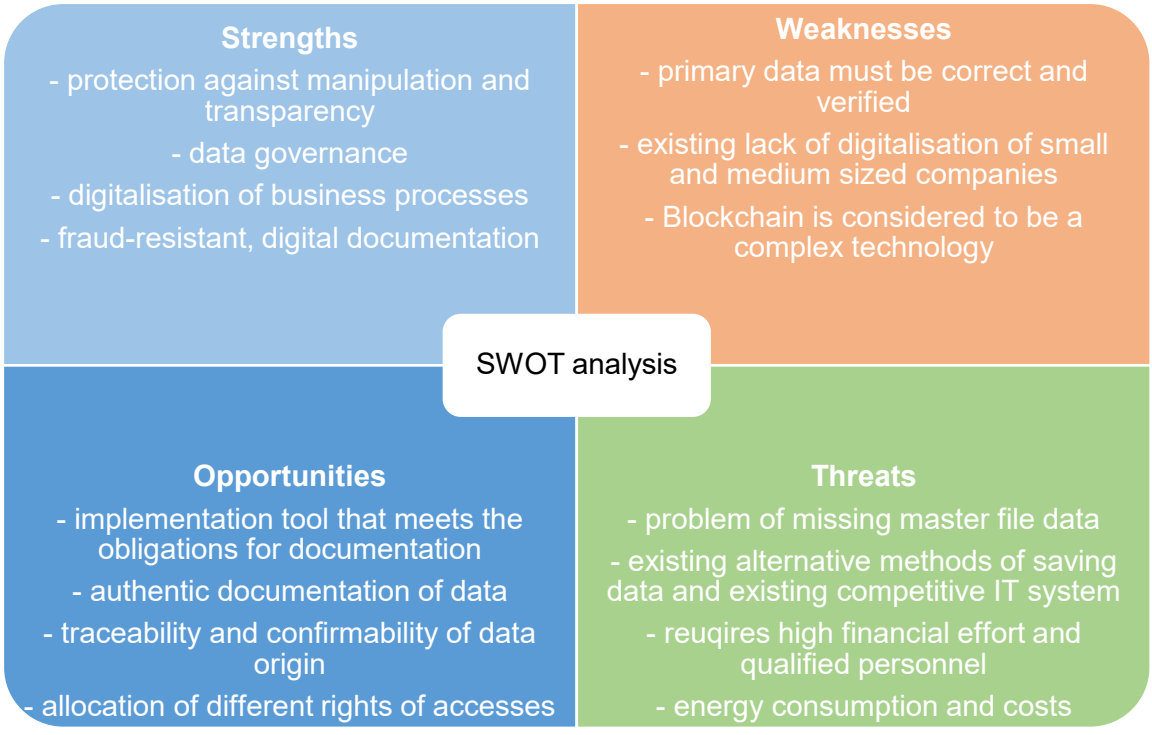

Fig. 1 SWOT analysis of the Blockchain technology in the context of textile logistics.

Due to multiple heterogeneous and globalized stakeholders along the textile supply chain, the Blockchain technology could be applied in terms of customs handling. When using the Blockchain in the form of smart contracts, financial flows along the supply chain network could be coordinated and automated if all necessary documents are saved. The precondition for the application of the Blockchain is a high degree of digitalization of all parties involved. Clothing manufacturers in the luxury and high-class market segment can use the technology to protect their trademark as intellectual property and combat product piracy and copying on the black market through authenticated product labels. The textile

and clothing recycling industry offers potential areas of application, for example storing information about the material composition of clothes in a decentralized database. Personal protective equipment, medical textiles or clothes for toddlers that have to meet certain quality standards may be equipped with product tags that are connected to the Blockchain technology proving that safety requirements or certificates are real and have not been compromised. The European directive on care labels demands a documented evidence of origin that can be realized by applying the Blockchain technology as well.

Basically, the cost-benefit ratio of implementing the Blockchain technology must be evaluated for every individual use case. The technology offers great potential to increase transparency, simplify communication and sharing important data along the textile supply chain.

4.2 Vision of the future of Blockchain in textile logistics

A comprehensive vision of the future shows an ensemble of various use cases of the Blockchain technology in textile logistics along the example of a global supply chain scenario for cotton jeans. Figure 2 illustrates the correspondent global value chain comprising several flows of goods and production processes.

In the case of cotton farming in Kazakhstan, for example, farmers could already store information about their organic farming practices in a Blockchain-based database. Moreover, the information of the last corporate social responsibility audit at the cotton production farm can be stored to provide further information to the suppliers' network. Thus, all parties involved are informed about the quality parameters of the raw material and know when the last audit was performed. Data sovereignty in the Blockchain allows different access to be granted to different parties of interest of the value chain. For the export of cotton to Turkey, all necessary customs data could be stored which enables a digitalized clearance and prevents delays due to missing documents or missing proof of the documents. Through the use of the Blockchain technology, goods and financial flows would only be released when the required documents are complete and their authenticity is proven using the Blockchain. The transport to China, where the dyeing and finishing of the yarn takes place, all customs data and proofs of audits may be controlled via the Blockchain technology. Information about the ingredients of the used dye in China could be saved. When unpredictable events occur along the supply chain, for example the blockade of the Suez Canal in 2021, the suppliers' network may be informed fast and easily in case the Blockchain is used as suppliers' network platform. The Blockchain technology can help to optimize risk management by identifying potential risks along the global supply chain at an early stage, for example due to missing documents. After the fabric production in Poland, the manufacturing process of the cotton jeans takes place in Bangladesh. Information about the working conditions and quality standards during these processes could also be stored in the decentralized database. A subsequent manipulation of the information is impossible. Afterwards, the final finishing of the jeans takes place in China. Also in this case, information about the used chemicals as well as seals or certificates could be stored on the Blockchain. Finally, the cotton jeans are ready for retail and are exported to Belgium and further distributed to Germany. On the sales market the end customers may profit from the Blockchain technology in case the clothes are equipped with RFID tags or QR codes that offer information about the global supply chain, the carbon footprint of the product or hints about the recycling in case they would be linked with the Blockchain network. Hence, not only companies but also final customers may profit from the application of the technology.

Fig. 2 The global value chain exemplifying the production of a cotton jeans (own illustration following [17]).

5 Conclusions

Within the context of textile logistics and global supply chains, the Blockchain technology offers various fields of application. These comprise:

- applying the Blockchain for protecting trademarks,
- applying the Blockchain for an implementation of seals of quality, certificates or quality assurance,
- applying the Blockchain to implement legal requirements, like the German LkSG,
- applying the Blockchain to control processes along globalized networks.

Each use case individually as well as a combination of them may offer advantages to the enterprises of the textile and clothing industry. The Blockchain technology enables companies, customers, retailers, suppliers and producers to improve their cooperation by a transparent and fraud-resistant exchange of information. Ideally, players of the clothing industry will profit from the use of the Blockchain technology in terms of supervising and controlling their supply chains and in terms of improving their speed of responsiveness on the global market. However, our research has shown that the current state of digitalization in many small and medium sized companies of the clothing industry in Germany is not high enough yet to implement a complex technology like Blockchain

Author Contributions

Natalie Fohrer and Andreas Gade were both equally involved in all terms of the research process, comprising the conceptualization, developing the research methodology, conducting expert interviews, analyzing the results of the interviews, investigation further information from various resources, data curation, writing, reviewing and editing as well as visualization. Markus Muschkiet served as supervisor and was involved in the final editing. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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