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INNOVATIVE VALUE CHAINS IN THE TEXTILE AND APPAREL INDUSTRY

Balancing sustainability and emerging technologies through the analysis of four cases

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Introduction

In today's world, characterized by high uncertainty and persistent changes and developments, global value chains are constantly evolving and adapting to new geopolitical situations and trends. (Betti and Hong, 2023)

Growing digitalization and greater awareness of companies and their impact on the environment have combined creativity and awareness into a strong innovation process, creating new types of value chains that can adapt to new challenges and reach new goals.

New technological developments and a greater commitment to more sustainable and ethical practices have particularly affected the Textile and Apparel industry, which is known as one of the most polluting and unsustainable industries. (European Parliament, 2020)

The textile and apparel value chains have adapted to current global challenges by seizing opportunities presented by new technologies and strengthening their commitment to a greener, more sustainable future. In many cases, technology and sustainability have reached a harmonious balance, reinforcing one another and driving innovation across the industry.

This research aims to explore the varying impacts that technological advancements and sustainability initiatives have on different types of textile value chains. By investigating these dynamics, the study seeks to uncover how emerging technologies and growing dedication to sustainable practices influence diverse value chain models and assess the potential synergies that arise from the intersection of these two forces.

This thesis examines three companies—Marzotto Group, Elbec, and Rifò—following an interview protocol, to showcase how different textile value chains have adapted to the evolving landscape of digitalization and sustainability. These cases highlight how companies are merging technological advancements and sustainable practices to achieve new milestones, driving continuous improvement toward a more sustainable future.

To further deepen my research, the case of Textilechain, a blockchain technology provider, was used to complement the analysis and give a different perspective on the research question.

Different value chains may have indeed diverse and multiple necessities, investing more in technological developments and innovations or managing better the sustainability part. A shorter supply chain can significantly improve the sustainable commitment thanks to the easier controlling and managing of the entire product life cycle, from the raw materials to the end usage.

There are also circular textile value chains, which are gaining much attention thanks to their numerous advantages and benefits created for the Fashion industry.

Finally, traceability and transparency, guaranteed by blockchain technology emerge as critical components for every type of textile value chain, thanks to the synergies, created by technology and sustainability.

The first chapter introduces global value chains (GVCs) and the main trends of the last years, highlighting changes and challenges and analyzing the impact of digitalization, sustainability, and twin transition.

The second chapter focuses on the Textile and Apparel value chain, providing a comprehensive overview of the Fashion Industry and its characteristics and main trends. It then provides significant insights into the impact of digitalization and sustainability on its value chain, presenting a clear picture of the industry's current state and future direction.

The third one is about blockchain technology emphasizing the critical role of integrating technological advancements and sustainability to achieve important milestones for the textile and apparel value chains.

Next, methodologies and the research part are discussed to deepen the literature research and give further insights into how digitalization and sustainability can have a different impact based on the type of value chain and how these two phenomena can intertwine to create further opportunities.

Chapter 1. Global Value Chains

1.1 How are the value chains evolving?

As economies around the world become more integrated and interdependent, understanding how Global Value Chains are evolving and learning what have been the main issues and trends during the last years, is of great importance.

GVCs explain how companies generate benefits and show the production network and distribution worldwide.

Thus, all nations and different organizations must learn more about GVC dynamics and improve their ability to adapt to the constant changes driven by the volatile market environment. (Zhan and Casella, 2020)

Even though Global Value Chains have a positive impact on the job creation process, the economic growth of a country and even improve the firm's performance, they are now undergoing numerous changes and challenges caused by the diffusion of technological developments, higher economic nationalism, and the growing awareness of consumers and producers for sustainability issues. (Betti and Hong, 2023)

The appearance and diffusion of digitalization, geopolitical issues, sustainability, new environmental protection requirements and the constant changes in consumer preferences and tastes are in fact the main challenges, that have impacted GVCs around the globe.

To withstand such challenges, strong value chains have proven to be those that seek resilience, adaptability, and versatility as their main characteristics and strengths. (Willcocks, 2016)

The COVID-19 pandemic and the war in Ukraine have highlighted some fragilities within global value chains too, forcing firms and businesses to additionally strengthen and fortify them or even rethink their way of doing things, bringing closer or back to the home countries some facilities and parts of the production. This means gaining more control

and reducing the risks of loss and disruptions caused by unexpected events. (Allgood and Per Kristian Hong, 2024)

Even the European Commission has established new rules and norms regarding the European market, reinforcing the European Industrial Autonomy and the Green Transition and supporting the creation of European Value Chains (EVCs) within several important industries.

The main objective is to promote the development of stronger and more sustainable supply chains, which can cope with constant challenges and risks, meanwhile safeguarding the surrounding environment.

To further support the development of EVCs, the European Commission has promoted the "Interregional Innovation Investments Initiative", which motivates the expansion and the progress of interregional innovation projects and value chains helping private sector involvement and growth.

Reshoring and Nearshoring represent an important opportunity to additionally boost these projects and increase the overall value added and the competitive advantage of European value chains. (Santini, 2022)

Different regions, economies, and businesses need to be aware of the different challenges they could potentially face and at the same time have a clear picture of the European legislations and regulations to be capable of seizing new opportunities.

"Anticipatory innovation" is then the ability to recognize the possible challenges and the faculty of adaptation to future circumstances and could become the most important strength and tool within every industry value chain.

1.1.1 Major trends in the last years

The literature has shown 4 main trends and phenomenons that will characterize global value chains and overall international productions, mainly dictated by technology, new policies, sustainability, and consumer shifts:

1. Reshoring and nearshoring will boost the rise of shorter and less fragmented value chains and value-added in higher geographical proximity and concentration.
2. Diversification will cause the dispersion of the economic activities distribution.
3. Regionalization will reduce the length of value chains but not their fragmentation.
4. Replication will create shorter value chains and tie together production stages, making activities geographically dispersed and a more concentrated value added.

- **Reshoring and nearshoring**

During the last decades, especially years, we have seen huge changes worldwide thanks to globalization.

The world has become in a certain way "smaller", the information now can flow faster from one part of the globe to the other and we can see how new developments and new technologies are taking over our lives and are shaping our everyday actions and behaviors. This is the main reason why companies and firms around the globe, mostly those who operate in international contexts and environments, are forced and required to "rethink" their corporate strategies, structures, procedures, and approaches to internationalization and diversification to design more efficient and effective ways as a response to a constantly changing world.

Dealing with the continuous challenging events and unforeseen circumstances that nowadays can occur in a much-unexpected way it's, for sure, not that simple and firms must be always ready to cope with uncertainty and technological developments.

Several events, including the Pandemic, the recovery in demand, the rise in energy prices intensified by the war in Ukraine, as well as the growing concern for climate change issues, have impacted the concept of globalization and made most companies profoundly change the way of operating and producing. (Santini, 2022)

This is why reshoring, which represents the return of production activities or parts of the supply chain that were previously outsourced, is gaining importance, and there has been a growing trend toward these practices after the COVID-19 crisis.

Even though the increasingly important phenomena of nearshoring and reshoring are similar to each other, they have some differences that are important to highlight.

Both are related to the concept of moving part of the production processes, that were outsourced to foreign countries, to the company's home country or closer countries. Reshoring refers to the practice of bringing these production or manufacturing processes back to the home country to improve quality, reduce costs, and create new job opportunities. Nearshoring refers, on the other side, to the reallocation of these processes to closer countries with some competitive advantages. (Allgood and Per Kristian Hong, 2024).

Companies are becoming more conscious about the risks and the issues of having suppliers on the other side of the world, and are trying to minimize this vulnerability and uncertainty by bringing them back closer to consumer markets. They are even taking into consideration the dependence on single-source suppliers. (UNCTAD, 2020)

- **Digitalization and Industry 4.0**

Technologies such as the Internet of Things, artificial intelligence, blockchain, and advanced robotics encourage better automation, efficiency, and visibility across supply chains building transparency among customers, suppliers, and partners. These technologies are widely adopted around the world, in different markets and different industries. (Rut and Ostafil, 2021)

They create many opportunities to improve not only the production processes but also give a crucial contribution to sustainability, helping companies to achieve greener value chains and adopt ethical and conscious practices throughout the entire value chain.

It has been shown that there is a strict correlation between technologies and sustainability, which could be of fundamental importance in the following years to be able to cope with new challenges. (Filocamo, 2017)

- **Increased regionalization**

Regionalization represents another important trend gaining more importance and refers to the moving from global supply chains model to one that gives more value to regional and local supply and production. This means moving closer to the home and consumer market.

Regionalization can boost value chains resilience, which is something relevant because of the constant instabilities and risks coming from the market. (Logistics, 2023)

Cost of transportation can be significantly reduced allowing companies to source and manufacture closer to their target market and they could improve the responsiveness and the adaptability to consumers tastes, as well as to different preferences and market changes.

Finally, there is a strong boost in sustainability and greener practices, as emissions can be reduced and stronger relationships with partners and suppliers can be established. In the meantime, companies might have a better understanding of the local regulations and requirements, instead of knowing many different rules and norms adopted by different countries and different perspectives around the world.

- **Sustainability and resilience**

Value chains are more and more subjected and exposed to environmental and social sustainability concerns and consumers and stakeholders want supply chains to be transparent and verifiable for every company and firm in various sectors and industries. (Siewers, Martínez-Zarzoso and Baghdadi, 2024)

Every country is establishing new rules and regulations that have a direct impact on the global value chains and how operations and manufacturing processes are being conducted and managed. (UNCTAD, 2023b)

- **Shifts in consumer preferences**

Changing consumer preferences, including preferences for customization, speed, and transparency, are influencing global value chains. This is driving companies to adopt flexible manufacturing processes and agile supply chain strategies to meet evolving consumer demands and respond to increasing responsible behaviour against environmental and social impact.

There is a growing interest in greener companies in diverse industries, which invest in transformation of their value chains to improve their impact on climate change and natural disasters.

- **Rise of e-commerce and direct-to-consumer models**

The growth of e-commerce platforms and direct-to-consumer (DTC) brands is reshaping traditional distribution channels and value chains. Many companies are avoiding intermediaries and are making direct relationships with their customers. This, in turn, changes their strategies, the value chains, and how the delivery of products to consumers is conducted.

- **Emergence of new trade routes and markets**

Overall, global value chains are becoming more dynamic, interconnected, and responsive to evolving economic, technological, and societal trends. Adaptability and agility are increasingly critical for companies to survive in this rapidly changing environment. (unctad.org, 2024)

Global trade routes have been influenced by the recent crisis, and factors such as trade simplification instruments and new technologies are fundamental to boosting and increasing goods transportation.

Geopolitical events have significantly influenced the traditional routes of transportation, lowering the amount of goods passing through the northern Eurasian corridors since the start of the war in Ukraine.

The Red Sea crisis has further increased the urge for firms to search for new alternative and diverse routes, and many new roads have emerged in recent years to improve the east-west trade.

1.2 Digitalization and GVC

In the literature, the term “digitalization” is often related to other synonyms, such as “digital economy”, “Industry 4.0” or “Fourth Industrial Revolution” and has various relevance and meanings depending on the organization and the sector of adoption.

Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, used the term “The 4th Industrial Revolution” at the World Economic Forum in Geneva in 2016 for the first time, highlighting the fact that this revolution has as its protagonists the newest technologies, which are Big Data, Internet of Things, 3D printing and Artificial Intelligence. He states that all of these innovations have an impact on the global value chains, including governments, businesses, civil societies, and individuals. (Marín et al., 2023)

Digital transformation refers to the process of incorporating and adopting digital technologies to improve the production process, and the customer experience and to better collect data and analyse them.

Digitalization has profoundly improved business operations and performances and has introduced numerous advantages and opportunities for different industries and in different sectors. (UNCTAD, 2023a)

Digital technologies have significantly affected Global value chains too and studies have shown that they improved the communication and interaction with suppliers and customers and boosted the development process of new innovative products and business models, creating new value propositions and reaching new successes. (Rut and Ostafil, 2021)

The adoption of digitalization and new technologies influences directly every part of the value chain creating significant improvements from the procurement of raw materials to the final distribution of the products. The overall efficiency and effectiveness can be boosted by improving quality, and relationships within and outside the organization, and finally providing many opportunities, and chances for extraordinary growth.

Based on the scientific literature and papers, new technologies and digitalization create new opportunities for growth and improvements and make businesses reach their

highest potential, regarding how they conduct the business and how they design and finally deliver the products.

These changes have also increased competitiveness and challenges in the market of every industry, because organizations may now have to deal with multiple distribution and selling channels, need to quickly adapt to the consumer's tastes, and keep the capacity of adaptation and responsiveness at high levels. (Donghyun, 2022)

To gain and then maintain this competitive advantage, organizations need to reach greater value lowering or maintaining the same costs. To minimize these costs and improve the overall value delivered to the final customers, it is important to analyze and examine carefully value chains and identify what are the main steps needed. (Rut and Ostafil, 2021)

Global value chains incorporate all the different production processes, tasks, and activities, which could be very fragmented and distributed around the world, coexisting and creating a system of different networks and chains that are present globally or in different countries.

Managing properly these value chains, creating a strong collaboration and integration between those functions that represent the core of activities and those that provide support, is what can enhance a company's performance, increase its value, and maximize the turnover and financial gains.

With the diffusion of these technologies, companies do not operate anymore as isolated entities, but they rather have and are linked to numerous suppliers, partners, and collaborators, which then creates a huge network with information flows and exchanges. Their activities and operations directly affect the other companies and entities. (Jona-Lasinio, Manzocchi and Sopranzetti, 2019)

Deciding for a company to introduce digitalization strategies requires a deep knowledge of its utility and capacity to improve the operations and processes, needing a huge amount of data and research.

A common strategy and a unified vision are fundamental tools during the procedure of digital transformation and every organization has its way of developing it to be able to stay competitive and profitable in the current industry.

Digital resources integration throughout the value chain offers ways of value creation, better competitiveness in the market, achievement of new goals and milestones, and the adoption of new business models. This is known as “digital strategy” and it is strictly related to the use of intangible resources in the business’s operations and a “resource-based” approach, increasing efficiency and market effectiveness.

A digital strategy highlights new aspects and features that change how value is created. These elements include processing multiple information, adopting multi-party business models, harmonizing and managing models across networks, and controlling network architecture (Bharadwaj et al. 2013).

One of the most important strengths of digitalization is the capacity to generate objective data and process them to make efficient process management decisions. This transformation is once again given by the constant changes in customer needs and the rising trend toward personalized products and services (MBF Group 2021).

In the end, though, everything is strictly related to data processing and management and how they are used. The main element is the connection created between these different data in favor of the development of digital solutions throughout the whole value chain as well as the production of the company's product. Exploitation of the most recent technology innovations and all the other components may be linked and controlled to enable the business to reach new levels of efficiency and even develop new sustainable and greener products.

This process starts with the introduction of advanced new products, that have reached higher quality and functionality, which makes consumers purchase them and have higher expectations. Other firms are now induced to adapt too, and recreate similar or even better products modifying their business models and how they operate. Something quite demanding.

In the following years, adopting these technologies and acknowledging the importance of Industry 4.0, is a fundamental step for every company within every sector and industry. It is something inevitable and will even gain more and more importance.

As anticipated by the “UN Trade and Development” organ, digitalization has and will have a higher impact on GVC manufacturing (UNCTAD).

It has been claimed that digitalization will decrease the demand for labor. Thus it will disadvantage developing nations since many will no longer be able to offer low labor prices and some firms might shift part of their operations to high-income economies.

Technology may also have an impact on how Industry 4.0 affects GVCs. The benefit of manufacturing in nations with cheap labor costs may be decreased by robots and computerized manufacturing. Similar to the way it was used to solve medical supply shortages during the COVID-19 epidemic, 3D printing could reduce GVCs and allow businesses to maintain production closer to markets.

New technologies could also result in barriers for new entrants into GVCs because of the increased knowledge, skilled labor costs, and capital investment required.

Although less than 5% of the examined enterprises were aware of Industry 4.0 technologies, UNIDO research conducted in five "latecomer" countries indicated that firms may still integrate the technology into their manufacturing processes and increase productivity.

With the ability to trace shipments and bridge inventories, digital technologies like IoT and AI may also enable more SMEs from developing nations to take part in GVCs, hence lowering trade costs. Businesses can use AI to identify the most cost-effective, environmentally friendly, and efficient international shipping routes. (UNCTAD)

It is fundamental to say that by far technologies from Industry 4.0 have been adopted mainly by the few leading economies, with the majority of the patents pertaining to 10 high-income countries. However, the use and adoption of new technologies depend not only on the country but also on the sector and the industry. There are industries more likely to be advanced and to have the urge to constantly adapt to discoveries, such as the computer and the machinery industry.

Is important also to mention the fact that countries with a strong presence of manufacturing industries and high levels of skills are more likely to improve and move to smart production. (UNCTAD, 2023a)

Recent research has also focused on the consequences that digital transformations have on sustainable entrepreneurship and how digital technologies and sustainable business models can be integrated towards the achievement of important goals and new opportunities.

1.3 Sustainability and GVC

Studies have shown that global value chains impact the environment and have a massive ecological footprint. It is thus fundamental to engage the companies in a process called "the greening of the global value chains".

The achievement of the "Paris Agreement objectives", which sets long-term goals, the reduction of the overall harm caused to the environment as well as global GHG emissions, and a lower level of overexploitation of existing natural resources are just a few of the steps to be taken. (United Nations, 2023)

Global value chains affect the environment in different ways and have different effects, known as scale, composition, and technique. These are related to the rise of transportation and travel volumes. (Joint Research Centre, 2022)

The creation of green and strategic industrial ecosystems is prioritized by the New European Innovation Agenda, the European Green Deal, and the European Industrial Strategy to facilitate digital and twin transitions and new opportunities and improvements. (Rabellotti, 2023)

The Helsinki-Uusimaa region now has a chance to support the expansion of a sustainable textile sector according to the recently announced EU Strategy for Sustainable Textiles.

The textile sector needs to be transformed into a more sustainable business. Only food, housing, and mobility have a greater environmental and climate change impact in Europe than the usage of textiles. The EU's textile and apparel sector continues to be a major driver of economic growth and has the potential to further improve the circular economy. With a revenue of EUR 162 billion in 2019, this industry employs 1.5 million people and is made up of approximately 160.000 enterprises. In the 1980s and 1990s, Helsinki-

Uusimaa's textile sector, like that of many other European regions, was forced to relocate to less expensive nations like China.

1.4 Twin transition and GVC

To be able to respond efficiently to these continuous challenges and developments, it is fundamental for industries to invest not only in technological innovations but also in new sustainable solutions that can boost overall efficiency and allow them to respond quickly to disruptions and uncertainty. (UNCTAD, 2023)

During the last year, there has been a growing interest in a new phenomenon called “the twin transition” that highlights the interconnectedness between green and sustainable policies and technological developments. Both parts can enhance each other and make firms more competitive with a lower environmental impact. These transformations can support each other and are associated with concerns over environmental and technological upgrading, hence the greening of global value chains by integrating frontier technologies mainly related to Industry 4.0. (Daehlen, 2023)

Global value chains are at the centre of activities in the global economy, accounting for about two-thirds of international trade flows and recently there has been a growing interest in the benefits they could get from the twin transition.

Upgrading driven by new regulatory changes, consumer demands, and social standards is increasingly based on new designs, standards, and specifications that need to be applied throughout the entire value chain. (European Commission, 2022)

The greening of global value chains can be supported by digitization in increasing productivity and safety, reducing environmental impacts, and nurturing new business models grounded on the circular economy.

The diffusion of new technologies such as Big Data, IoT, 3D printing, advanced robotics, Artificial Intelligence, and blockchain can incredibly improve production and, at the same time, contribute to lower carbon emissions and promote greener policies. They have the power to help businesses achieve their environmental goals and become as sustainable as possible.

3D printing can be exploited to lower fuel consumption thanks to the aircraft's weight. Artificial Intelligence can boost the use of green energy for smart grids, and blockchain gives significant advantages to firms that want to become more sustainable and make their value chain as transparent as possible.

These higher standards can have both opportunities and limitations for producers, some might be able to have benefits and realign according to the new opportunities, while others may be left out of the value chain.

As a result, latecomer countries find it hard to adopt Industry 4.0 technologies, which have been largely produced and diffused in leading economies such as China, the USA, and Western Europe.

Levels of high-skill employment and the share of high-skill, technology-intensive exports are some ways, through which a country's readiness can be measured. Most of these high-technology industries are unavailable to most developing nations. (UNCTAD, 2023b)

The latter needs to integrate green and digital strategies in developing countries through coordinated policies in the fields of energy, environment, industry, and foreign investment settings that motivate the adoption of green technologies. They must develop their digital infrastructure and skills by ensuring access to the internet, mobile networks, electricity, and human capital while supporting skills development for adopting and adapting to the new technologies. (European Commission, 2022)

This means creating international partnerships to promote digital technology acquisition and knowledge transfer of technologies like AI, IoT, robotics, and blockchain. Standards and regulations that are created in international norms may promote cooperation, thereby raising productivity and fostering environmental sustainability through financing incentives. Projects should clearly show the return on investment, while coordination of public sector initiatives would contribute funding and give necessary technical support in partnerships with international donors. Infrastructure improvement, together with the backing for green and digital technologies, has the potential to attract foreign direct investment.

As already said, industry 4.0 technologies can improve not only the overall productivity of a firm but also its environmental impact, by reducing the carbon footprint and

promoting the adoption of new green technologies and the implementation of circular economy business models. (European Commission, 2022)

The more advanced technologies can be divided into two different groups: smart manufacturing and services technologies and data processing technologies. The first type allows robotization and the division of tasks, while the other promotes interconnectedness and data exchange.

All of these new technologies can upgrade GVCs, creating significant environmental improvements and reducing carbon emissions by observing standards, managing logistics more efficiently, boosting operating efficiency, and enhancing the design. (Ali et al., 2023)

Technologies such as big data, artificial intelligence, and blockchain can help reduce the environmental impact and can contribute to the fight against climate change if effectively implemented inside business operations and activities, especially in assembly industries.

To be able to fully exploit these technologies, latecomer countries will be required to have a stronger digital competency and have supporting infrastructures and institutions. The time and the effectiveness of adoption will depend on governments, technological and productive capacities, and the level of advancement and evolution of a country.

Policies and environmental regulations are really important to incentivize countries to adopt green technologies and exploit their potential and opportunities related to the twin transition, as many countries have shown a concrete missing in this field. (UNCTAD, 2023a)

As shown by many studies this strong relation between investments in digitalization and environmental impacts can boost the overall performance of firms. It depends upon industries but the majority of firms that use digital technology to enhance their business models and add more value, are very likely to become more sustainable and reduce their impacts. Ma et al. (2022) and Mondejar et al. (2021) wrote about the power of digitalization in improving growth in green policies and reducing CO2 emissions. These types of technologies can reduce geographical distance, and the spread of environmental information and have positive effects on the execution of environmental policies.

The exploitation of digital technologies can thus lead the global value chain to be not only more productive and efficient but also to make countries go greener by participating in global value chains, mainly in the most developed and industrialized countries.

Chapter 2. The textile and apparel value chain

2.1 Fashion Industry Overview

2.1.1 Overview

The Fashion Industry generates an economy of 3 trillion dollars and contributes to 2% of the world's domestic product.

As the world's population increases to a projected 8.5 billion people by 2030, annual global apparel consumption could rise by 63%, from 62 million tonnes today to 102 million tonnes—equivalent to more than 500 billion additional T-shirts. (McKinsey & Company, 2023)

The industry employs 60-75 million people worldwide, coming up to 300 million throughout the entire value chain. There is an estimation of household expenditure in the European Union accounting for 5.6% spent on clothes and footwear.

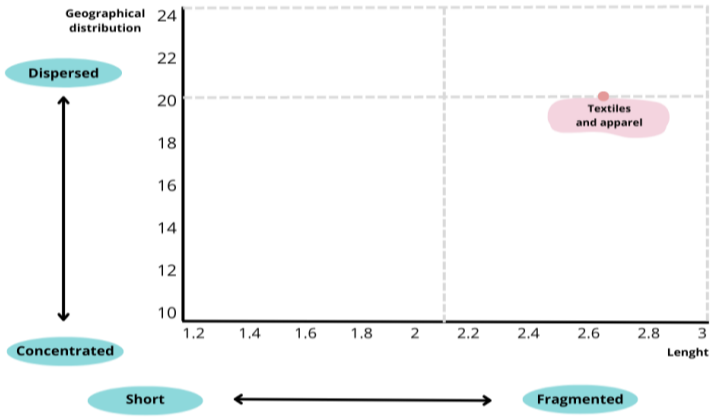
The European textile and clothing industry has about 160.000 companies that employ 1.5 million people with a turnover of $162 billion. (European Commission, 2023)

In the last years the sales have been rising, which is a positive consequence of the improvement of goods sold, their new capabilities and numerous innovations.

The fashion industry has passed through several changes and developments in recent years and has reached a higher economic profit in 2022 compared to previous years, confirming the positive trend of growth.

The value chain of the industry, as shown in Figure 1 (The Textile and Apparel value chain), is fragmented and complex with geographically dispersed production and a high exposure to risks and changes in the market. (State Secretariat for Economic Affairs SECO, 2021)

Figure 1, the Textile and Apparel Value Chain



Source: Own Elaboration

It has a fundamental role from the designing to the selling of clothes and garments and, even though it includes numerous sectors and has such a huge impact on the economy, it lacks concern for social and environmental issues because of the emissions that it causes, the water consumption and the waste production. (Akram et al., 2022)

2.1.2 Changes and Challenges

The textile and clothing industry has a long and complex value chain that includes different steps from the making of fibers into yarn, to fabrics and the final products. The sector is undergoing an intensive change with many innovations related to the 4.0 industrial revolution and digitalization, which are changing profoundly the industry creating new opportunities and making room for further improvements. (ApparelMagic, 2023)

Since the pandemic, there have been major changes in the industry, as global value chains have been going through disruptions, and there have been numerous changes in supplier choices and a change in consumer behaviors.

Other factors, which include new technological advancements and expansion, a greater sustainability concern, and new ethical regulations, are causing the Fashion Industry to transform and adapt to all of these innovations. Brands need to be able to be constantly

informed about the main industry trends and adapt accordingly to boost every possible chance of improvement.

Differences in growth came from different performances of countries throughout the last years and for instance, in the case of the US and Europe, growth remained low throughout the whole year of 2023. However, China's strong performance in the first half gradually faded away in the latter half. The climate emergency is still a very wide concern, particularly as a consequence of last year's weather catastrophes. By 2024, most companies expect to enhance and improve their adaptation and resiliency to climate impacts. One of the main objectives would be to improve sales thanks to innovations in pricing and promotional strategies, due to the ineffectiveness of measures for cost-cutting. (UNEP, 2023)

There are expectations for decreasing demand that have been seen over the years in 2024 as well. Such periods are often considered to be 'bullwhip' periods in supply chains where minor sales fluctuations lead to drastic changes. This has many consequences such as empty factories, people losing their jobs, and long wait periods for infrastructure investment.

To meet these difficulties, fashion businesses need to develop more clear and cooperative connections with their raw material suppliers. In addition, companies will focus on greater efforts toward global warming and waste challenges as they create and build new efficient business strategies to prevent environmental disasters. (McKinsey & Company, 2023)

At the same time, brands might find that the consumers begin to be more careful regarding the basic principles of authenticity, and this may cause further challenges.

Such an evolution will create a significant change in the fashion environment favouring more unconventional and exposed influencers. It would be smart for brands to adapt to this phenomenon and create collaborations with these new content creators to enhance their narratives. (Gereffi and Memedovic, 2023)

With consumers ready to start traveling again with greater enthusiasm than before in the coming year, the fashion industry will have to rethink how it connects with customers in different countries. For the first year since COVID, the volume of travel in 2024 will exceed the one in 2019.

This will cause consumers to have more expectations related to their shopping and will cause brands to reconsider their distribution strategies and be able to meet their customers in whatever place.

New regulations and rules about sustainability will shape the industry in different ways and impact brands and firms on different activities and aspects of their business operations. These activities will include an increase in initiatives aimed at reducing emissions and environmental impact.

Many protagonists of the fast-fashion industry, like Shein and Temu, may have serious issues and problems related to the upcoming rules and directives. There are many growth potentials, in different aspects of the industry, which include new technologies, sustainability, marketing, and changing consumer behaviors.

“Uncertainty” is considered the word that defines in the best way the next period related to the apparel and textile value chain. The main drivers of this phenomenon are the continuous geopolitical events, weak economies, and the increase in interest rates. Sustainability has the strongest impact on the execution of business plans and remains one of the most important aspects where to invest to remain competitive and still operate more consciously and under the fast-moving and changing regulations and rules.

Another important aspect to be considered is artificial intelligence and its potential in the textile value chain as it could be exploited very efficiently in the different phases of production and in the design and marketing aspects, which help improve brand credibility and story-telling and also increase product differentiation.

The key insights presented in “The State of Fashion” report show that Global GDP growth is set to slow to 2.9 percent in 2024, with less respect to the 2 percent in 2023 and 3.5 percent in 2022. Regarding consumers' spending, in China there is a positive net intent to purchase apparel, but negative in the US and Europe (including France, Italy, Spain, Germany, and the UK). (McKinsey & Company, 2023)

The apparel industry has to confront problems related to resource depletion (an occurrence that indicates the consumption and the use of a resource faster than the time it can be replenished). The imminent effects of these phenomena will force brands to reconsider their business planning and introduce more sustainable practices, making an effort towards recycling and new regenerative materials. This means using alternative

textiles and materials from different types of fibers that offer a more conscious production and an improvement in the brand's sustainability.

One of the main trends of recent years is to use smart fabrics that include technologies such as flex circuits (flexible electronics), sensors, and actuators that are incorporated directly into textiles. Clothes in fact will be designed not only to be fashionable but will also be intelligent and able to interact with devices and potentially monitor health. These types of technological advancements will create new opportunities and make the production of textiles even more conscious and with more benefits not only for people but also for the overall environment.

Another key role is played by biotechnology within the textile industry. This phenomenon will create further opportunities to offer consumers sustainable clothing and fabrics that do not include artificial dyeing methods but are more natural and effective, which in turn can create benefits to reduce the overall impact and pollution of brands. (ApparelMagic, 2023)

Gender fluidity in fashion is yet another concept that has faced curiosity as it presents opportunities for inclusivity and diversity in fashion. As this phenomenon is closely related to sustainable clothing, consumers are more aware of their purchases and overall consumption. These exploitation and use of digital models are providing new opportunities for people to buy and for companies and brands to become more environmentally friendly thanks to fewer returns and virtual fittings.

With these expanded sales channels, both gender-fluid and sustainable fashion become more readily available to shoppers and enable them to buy according to their principles and preferences.

Among other increasing developments that are being embraced and that give room for more integration of digitization into the textile industry is the fashion metaverse. In this digital environment, people can create their outfits and change the clothes worn by the avatars. This shows even more how the integration of the textile industry and technology has become more and more significant.

Augmented reality is also enjoying enormous success and is creating big changes, especially regarding the pre-purchase part and therefore the visualization of clothes that allows customers to interact differently with brands and have a greater awareness of

what they are going to buy. This improves the entire experience and interaction within the purchasing process and in this way returns and also waste in the environment are reduced.

It also underlines a strong relationship between new technologies and sustainability, because they not only improve the consumer experience but also create a series of advantages for the environment and fight the battle against emissions and waste, which in the textile industry is a big problem.

As far as business management is concerned, ERP and PLM technology have an increasingly prominent importance and help brands manage complex operations promote greater awareness, and facilitate the process of making a decision. Not only is efficiency improved, but above all the ability to be adaptable and respond more quickly to imminent risks in the market, which is increasingly volatile.

3D printing and robotics are two other types of technological innovations that are transforming the apparel value chain and are creating more and more opportunities for boosting the efficiency of the firms and making more room for environmental improvements and awareness.

The traditional model that represents the fashion industry is linear and is made of three phases: buy, use and dispose. (McKinsey & Company, 2023)

However, Circular Fashion is a trend that in 2024 has gotten a lot of attention and encourages a different lifecycle for clothes and garments, making it more sustainable. Consumers are now more aware of the problems related to the industry and are willing to buy second-hand clothes or purchase from brands that have adopted circularity in their business models, reducing waste and expanding the lifespan of clothing. The use of technology, such as blockchain, is even more fundamental to verify the entire value chain of materials and their composition and profoundly promotes circular business models.

2.2 Sustainability in the Textile and Apparel Value Chain

The current fashion system is unsustainable, and is impossible to think that firms may continue to operate as they do now. (Petrak, Mahnić Naglić, Maja and Rogale, 2023)

It has been estimated that the global fashion industry consumes around 93 billion cubic meters of water to produce textiles each year, causing 1.7 billion tonnes of greenhouse gas emissions. What is also important to highlight is that 1 quarter of the industry resources are wasted as fabrics and garment leftovers and $140 million worth of clothing goes to landfill each year.

The worsening of weather conditions in 2023 has urged the need to be more and more conscious about the impact that we as human beings have and how every type of industry plays a different role in the fight against climate change and pollution. (DHL InMotion, n.d.)

It has been widely discussed that the fashion industry is one of the most polluting and its value chain has become even more vulnerable. The main problems are related to resource consumption, water and air pollution, and pollution from solid waste production. It is also very relevant to consider the phenomenon of fast fashion which has revolutionized the industry by creating clothes and textiles always available in new styles, shapes, and colors at very low prices; this causes a huge increase in production but also in waste and clothing being produced and at the same time discarded. (Meier, 2021)

As mentioned in “The State of Fashion 2024”, the Fashion industry is responsible for between 3 percent and 8 percent of total greenhouse gas emissions. Extreme weather conditions are expected to harm $65 billion worth of apparel exports and eliminate millions of jobs in 4 different economies that are the most central to the global fashion industry. Other issues that create concern are related to economic uncertainty, geopolitical tensions, and inflation. (McKinsey & Company, 2023)

For many different brands and fashion businesses dealing with climate risks is becoming an imperative and it is something viewed as an imminent potential problem to be solved, and not as a long-term goal. The most famous brands are investing around the world in new resources, technologies, and business models that could help them become more

environmentally friendly. However, it remains something highly debated and discussed, as there are many issues related to the phenomenon of greenwashing, the truth behind brands' campaigns, and their real commitment to the battle against climate change. (Weilin Xu , Fu (Jeff) Jia , Lujie Chen , Tobias Schoenherr, 2024)

The entire fashion value chain is exposed to the risks and harms that extreme weather conditions can have and one part that is even more sensible to these disruptions is the production of raw materials. If we take into consideration cotton, which is highly affected by climate disasters such as droughts and flooding, it is possible to imagine how the next part of the value chain could be negatively affected, forcing factories to close and threatening workers' safety standards. Climate changes are affecting the entire value chain and productivity, making it almost impossible to work in some countries due to the rise of temperatures and heat stress.

Fashion logistics strategies are also in danger as extreme weather conditions threaten the shipping of garments to their final destination. Investments in brands will comprise innovations in materials, a more conscious usage of the products, and better life cycle management.

Every day new rules appear in the fashion industry related to production and chemical use recycling and waste.

The European Union's flagship Eco Design for Sustainable Products and Regulation defines obligations related to design built around recyclability, durability, reusability, reparability, and the use of dangerous substances. In the following years will even be compulsory for textiles and clothes to have digital passports specifying all of the type of processes and substances that have been used to make the final products.

All of these aspects will be verified and controlled by certain bodies and directives, and regulations that will combat the phenomenon of greenwashing forcing brands to be honest and prove clearly whether they are sustainable or not. (European Parliament, 2019)

Waste is another important aspect to be considered as the majority of unused clothes or products that have come to the end of their lifecycles are being thrown in some countries harming considerably the environment. The Waste Framework Directive has already been amended and requires companies to be aware of textile waste by financing their

collection, sorting, and recycling. This is already present in France and will be compulsory in all EU countries by 2025. (European Parliament, 2020)

Although every company and brand tries to align their operations with environmental standards and directives, there is a lack of comparability that makes it harder for firms to know what type of activities are to be considered sustainable and what not. The CSDR sets common reporting rules and requires data and analysis that will need to be accurately reported. In this case, traceability technologies, like blockchain, will become more valuable in helping companies achieve the standards set and enable brands to be more transparent and open about their value chain. (Khamisani and Mattila, 2023)

Higher levels of consumption, which are continuously rising, require a higher usage and exploitation of natural resources, and as production is expected to rise at a constant pace there is a high risk of having even more unused textiles and clothes.

2.3 Digitalization and Textile Industry

New technologies and digitalization are bringing many opportunities within the clothing industry. Opportunities related not only to the improvement of efficiency and productivity, but also new discoveries, new textiles and new opportunities to be more sustainable. The automation will even make possible the reallocation of some production activities to developed countries. (Conisti, 2022)

The lifecycle of clothes is shorter than it has been previously and digitalization and automation can improve and potentially help the textile and apparel value chain by redesigning industrial processes, making manufacturing more efficient and boost the productivity levels. The machine now used in the industry are all endowed with smart platforms able to collect and analyse data and are helping firms become quicker and adaptable in facing market changes and needs.

The integration of industry 4.0 technologies inside the supply chain can bring significant improvements to the fight against climate change and pollution, benefiting sustainability practices and policies. These technologies can increase production and profit while

safeguarding the environment and making sure the value chain is transparent with a better social impact. These technologies support the entire value chain, by helping with the decisions about technologies, processes, and resources to be used, all of which are related to environmental performance. (Deepthi and Bansal, 2022)

The textile manufacturing industry has proved to be slower in regard with aligning novelties of digitalization respect to other industries and sectors. However, many technologies represent a real opportunity for the sector and next-generation textile machines are now becoming more and more digitalized integrating capabilities of Artificial Intelligence and Internet of Things. Thanks to these, it possible to track the entire production process and make reports in real-time with other important functions. (Casciani, Chkanikova and Pal, 2022)

The IoT technology enhances the decision-making process and gives many data based on real-time information and a deep analysis. The adoption of this technology is more frequent and the increase of smart factories in textile manufacturing is a sign of an industry that is turning to new technologies and is ready to exploit entirely their potential for the production process and every part of the supply chain.

It is now common to hear about Artificial Intelligence and the huge potential that it represents for every kind of industry and sector. Related to the textile value chain AI can process many data and enhance the production process from the manufacturing and purchasing of raw materials to the marketing and the logistics parts. (Ferlito, 2024)

The business plants are now equipped with automated and robotic machines capable of recreating the work of a human being, at times even more efficiently. Artificial intelligence favors greater precision and strong accuracy that enhances the textile industry. Manufacturers can improve the productivity and the quality of their final products and can achieve better results in terms of sustainability and environmental impact, reducing waste and scraps.

Another phenomenon that is present in this industry is “Technological Convergence”, as different technologies are converging and are becoming more interconnected and represent a big potential for the production and development of smart clothing. 3D printing is also expected to have potential in the industry, as it can boost production and make brands respond faster to customer demands. (UNCTAD, 2023b)

Aspects such as electroactive polymers, with nanotechnology and plasma technology will be more exploited by the industry and new fibers and filaments will provide more and more capabilities and improvements for the textiles.

It will mostly be employed for high fashion and numerous applications and opportunities will be possible with the integration of electronic capabilities inside the textiles. This will present numerous chances in favour of the sector's transformation, an increased production automation and robotization and the exploitation of AI.

As previously said, The Sustainable Development Goals of United Nations are important achievements that every industry should prioritize, especially the Fashion industry as it generates an economy of 3 trillion dollars and it contributes to 2% of the world's GDP. Sustainability should be integrated in the business process to promote fashionable but sustainable products and innovation and a higher awareness should be at the centre of attention.

There is a strong link between digitalization and sustainability as the emerging technologies, such as Internet of Things, Artificial Intelligence, blockchain, Augmented Reality and Virtual reality, are capable of significantly enhancing the capability of the industry to achieve the sustainable goals. (Lee, Park and Vu, 2021)

The European Commission has predicted the rise of smart clothing expecting them to be more innovative and fashionable at the same time, with new features and new capabilities empowered by electronic chips, sensors, and energy-efficient connectivity protocols. The development of smart clothes will enable people to have more data related to health and physical activities and be able to monitor and track numerous aspects of their daily activities.

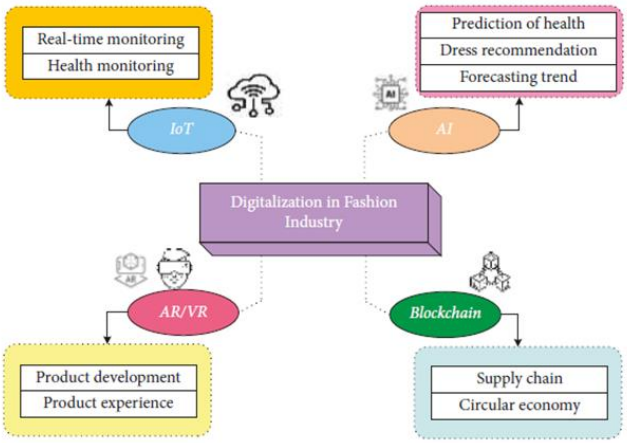
AI is already able to make forecasts about the weather and give recommendations on how one should be dressed. IoT and Blockchain permit an effective tracking of activities and promoting at the same time a circular economy extending the life cycle of a product. The AR and VR technologies enhance the costumer experience by making the purchasing process more interacting with the possibility to try the products inside the virtual world and enter the stores from a home device. (Lee, Park and Vu, 2021)

Even though there are many benefits, the literature says that there is still so much work going on, as every day there are novelties and the technologies are constantly evolving in

favour of the industry efficiency and the overall economy. However, it is certain that the potential is huge and textile firms and brands will be able to improve their operations and surpass new obstacles and barriers aiming at becoming even more sustainable.

Figure 2 highlights the main digital technologies relevant for the fashion industry and their applications and potential.

Figure 2, The application of digitalization in the Fashion Industry



Source: (Akram et al., 2022)

The IoT creates a network of interconnected devices that are made with sensors, computing power, and programming and can communicate exchange, and collect data.

Artificial Intelligence replicates the human decision-making process achieving things such as prediction of health, dress recommendations, and forecasting trends. (Akram et al., 2022)

Blockchain is fundamental for the fashion Value Chain as even more industries are now trying to implement this technology to make data more secure and verifiable thus eliminating information asymmetry, enhancing visibility and traceability, and promoting sustainable practices.

Finally, Augmented Reality and Virtual Reality represent an upgraded version of the world with other elements such as music and simulations being inserted. Thus, a person can enter this world and access virtual try-ons to see their clothes and enhance the purchase decision.

Augmented Reality, on the other side, merges the real world with other computer-generated features and people can try their clothes without leaving their homes.

2.4 Long and short supply chains in fashion

An important thing to reflect on is how a short supply chain in the textile and clothing industry could represent a significant opportunity for environmental issues and could be the solution to many different problems. In the last years, when global value chains have been going through numerous changes driven by geopolitical tensions, sustainability issues and technological developments, reshoring, and nearshoring have represented for textile firms an efficient strategy to bring back or bring a closer part of the production.

This helps them to better manage the entire value chain and keep track of the different processes, while at the same time achieving higher levels of transparency and sustainability. (Santini, 2022)

The main problems related to the long fashion supply chains are long lead times, which often create an excess in production with respect to the actual demand and an excess of the products in inventory. Then a non-transparent group of suppliers to reduce costs and still the use of outdated technologies that represent an obstacle for innovation in many different cases. (Fleischer, 2023)

Usually what brands present during fashion weeks in trade fairs in a year, is actually what is going to be sold in the next one. However, considering how volatile and unpredictable the world is right now, it often happens that the orders and the predictions of the previous year do not match the actual demand and requests for that specific product. This results in a huge number of unsold stock and, according to a McKinsey survey, 20% of all the garments produced, do not arrive to the final consumers.

Another important statistic is related to the investment in technology of fashion brands with only 1.6-1.8 % of investment made in technology, which is a number expected to rise by 2030.

A long supply chain is usually an obstacle to knowing exactly the origin of raw materials. Furthermore, it could harm the traceability process.

A shorter supply chain can represent an opportunity to boost flexibility and control and help brands adapt faster to market changes and adopt sustainable practices to meet directives and legislation objectives. This would highlight the importance of insourcing production, as mentioned in "The State of Fashion 2023".

The adoption of zero-kilometre solutions is also relevant in guaranteeing services at its historically high levels creating a better reputation in favour of the environment. Originally the fashion industry has been relocating part of the production, especially for margins and lower labor costs. However, considering the many changes that affected value chains and numerous economic and political uncertainties, it has been more profitable for brands to turn to shorter supply chains, making reshoring more profitable and containing at the same time overproduction, as they can better forecast demand. (Maile and Staritz, 2024)

These practices improve quality and timing and simultaneously make brands invest in the values of Italianness with profitable returns in terms of efficiency.

2.5 Overconsumption in fashion and how can it be solved?

Overproduction, as one of the main characteristics of this industry, requires a huge investment and exploitation of resources such as energy, water, materials, and chemicals. At the same time, it has a huge impact on the environment creating a lot of waste. It has been estimated that only 1% of clothes, after their use, are recycled into new clothes, and technologies that allow clothes to be recycled into virgin fibers are something still being under study and investigation.

In Europe about 26 kilos of textile are produced and used and 11 kilos of them are wasted and discarded. The new strategies to deal with these issues are creating a new business model, investing in re-use and recycling, promoting circularity in fashion and convincing consumers to change their purchase behaviour towards more conscious shopping and more sustainable brands. (Vasquez, 2022)

Once analyzed all the impacts that the industry actually has, it is now important to see how there are numerous innovations, combining new technologies and new business

models, that allows the industry to improve and overcome these issues related to climate change and pollution, that every year become more relevant to address.

One possible solution of the problem could be creating products that have a longer life cycle and are more durable and at the same time invest in recycling, as not even 1% of waste coming from textiles is recycled into new garments. (European Parliament, 2020)

The amount of clothes that people use has been rising and it is expected to reach very high numbers and quantity. Fast fashion and the availability of cheap and always on-trend clothing have increased the urge to consume at extreme levels that cause damage to the environment not only in the production process but at the end of the life cycle too.

Cheap clothes are made of inexpensive synthetic materials, dangerous for the health of people and of the world. Polyester is made of fossil-fuel-based fibres with a production that has increased to 60 million tonnes in 2018 and the number will probably exceed 90 million tonnes by 2030. The production of this type of textile is responsible for a huge quantity of emissions and the World Resources Institute (WRI) has estimated that they will reach 1.588 Gt by 2030 if things do not change. Even though it has increased profits for many brands in the fashion industry, it came with the sacrifice of human health and the environment.

To be able to fight against these issues fashion industry should turn into a circular textile ecosystem that will motivate a reduction of virgin fiber production and boost innovations in materials, production, and investments in recycling of discarded fabrics and textiles. Increasing the length of a garment's lifecycle can help reduce greenhouse gas emissions footprint.

Consumers need to be more conscious about what they already have in their closets and increase consumption of the clothes they already possess, as they represent the most sustainable garments. On the other side, they have to be more conscious about what they are buying, searching not only for cheap or fashionable clothes but for clothes that are transparent about their origins and their production process. Only in this way, it would be possible to create a green environment and a cleaner and fairer fashion industry.

The European Commission has presented in 2022 a new strategy to make textiles "more durable, repairable, reusable and recyclable, tackle fast fashion and stimulate innovation within the sector" (European Parliament).

This strategy creates new obligations regarding the type of textiles, more transparency, and a new Digital Passport for clothes that will make brands increase their responsibility towards a reduction in the environmental impacts.

Other European Union measures include Ecolabels, which are ecological criteria that producers can add to their garments if they satisfy and reach minimum standards regarding substances and environmental impact. The Parliament has also approved the waste directive aimed at increasing producers' responsibility regarding their products along the entire value chain, even when they become waste, encouraging separate collection, sorting, and recycling.

Chapter 3. Technology and Sustainability for the Twin Transition in the Textile Industry

To overcome market uncertainties and constant challenges, digitalization and sustainability can merge and create numerous opportunities for the fashion and apparel value chains.

In the last years, traceability is a concept that has been widely discussed gaining more success and interest among the most important brands. Blockchain technology is one of the most appropriate examples of technological developments supporting sustainability throughout the entire value chain, promoting greening and improvement processes.

3.1 The importance of traceability

Traceability stands for transparency of the value chain and includes how a garment has been produced, from the initial design and material sourcing to the final delivery. Its significance for the fashion industry is more and more relevant as it enables companies to improve their commitment to sustainability and show the truth behind every product. (Gautam, 2023)

As already stated, the fashion industry damages the environment in several ways, and having the possibility to have verifiable and up-to-date data is fundamental for every clothing brand.

Traceability can be a real opportunity for both producers and consumers and potentially for people who have an interest in that brand.

Traceability is the process that represents the entire history of the product from its origins to the entire production process step by step. In this way, the supply chain becomes completely transparent providing true and reliable information, especially the ones related to the social and environmental goals aimed at obtaining certifications and obeying the regulations. (Michela Puddu, 2024)

However, it is not such a simple process, since it must provide detailed information regarding certifications, and the real impact and at the same time communicate the history of the final product to the consumer.

Altogether, traceability is a fundamental part of fashion business strategies as consumers require more information about what they buy and are more conscious about their purchases and, at the same time, new regulations and policies are becoming numerous and the need for this type of transparency will continue to grow. (Agrawal et al., 2021)

Supply chains can identify inefficiencies sort production or post-consumer waste and reduce risks to their finances and reputation by using traceability. Credibility and compliance are also guaranteed. Fashion actors can make informed decisions and actions with companies they know they can trust enabling them to progress toward a circular economy. Circular textile supply chains as opposed to traditional linear ones have the opportunity to achieve transparency right from the start with a solution customized for the use case. The business models and supply chains for the circular fashion industry have not yet reached a sufficient scale. Because of this, it is critical to begin traceability as soon as possible during the establishment of the supply chains. By doing this businesses can scale traceability with the circular model and related operations for a seamless successful implementation from day one avoiding the need to retro-engineer solutions.

Using traceability will give suppliers' brands and fast-moving recycling clothing companies a competitive edge and make it simpler for them to adhere to more stringent supply chain rules. (Studio, 2023)

Nowadays by establishing the requirements for what type of material input/content can be used, certifications are there to ensure that a garment is made from a specific material. However, they should be supported by another system to be truly reliable.

For example, there was a scandal about a factory in India producing fake organic cotton and the investigation revealed the use of inauthentic certifications.

To ensure all the information is reliable and safe, Blockchain technology represents a real opportunity to record all the transactions inside a digital database impossible to be tampered with.

It is possible to see how a type of technology can help support environmental goals through the entire value chain and the blockchain is a perfect example of this blend.

Commitment to sustainability goals and social responsibility can be guaranteed with the application of blockchain technology and brands can take advantage over competitors ensuring transparency and secure all the information along their value chains.

Nowadays, the two main trends, namely the growing awareness of consumers and on the other hand the increasingly strict rules on sustainability, lead brands, from the smallest to the most important ones, to scale down their strategies and turn their attention to practices that are less polluting and responsible towards the environment.

Realizing full product life cycle visibility from fiber origin to retail sale is one of the primary challenges. Verifying and establishing the sustainability of the manufactured and marketed clothing is especially difficult in the absence of an accurate system for tracking the materials used in fashion. (Redazione, 2023)

The textile industry (apparel and footwear) produces 4 billion tons of CO2, more than the total amount of international air and sea traffic each year according to the French Agency for Ecological Transition. (French Environment and Energy Management Agency, 2020) If present consumption patterns persist the textile industry will be accountable for 26% of worldwide greenhouse gas emissions by the year 2050.

The interest in blockchain technology has grown rapidly in the last period and it has been estimated that the trend will be accelerating, reaching $176 billion by 2025 of value generated and $3.1 trillion by 2030. (Agrawal et al., 2021)

The demand has increased significantly in various sectors, given the advantages and opportunities it provides.

Potential market barriers include issues with security and scalability unpredictability in regulations and challenges incorporating the technology into already-existing applications. The expansion of online transactions, the digitization of money, safe online payment, gateways, and the growing interest of the banking financial services, and insurance sectors in addition to businesses growing acceptance of cryptocurrencies as a form of payment are the main factors driving demand-side growth.

3.2 Blockchain technology

One of the most important prerequisites for multi-tier, multi-site manufacturing is traceability. It provides visibility and allows customers to control the quality and transparency of the product. Installing traceability is necessary to address the issues of low visibility and information asymmetry prevalent in the textile and garment sector and it is challenging for customers to obtain product information that can support moral purchasing decisions or guarantee the product's legitimacy. Furthermore, sharing sensitive data in an unsafe setting where there is a chance of data manipulation and apprehension about losing information advantage presents difficulties for all parties involved. In light of this, a blockchain-based architecture for traceability in multitier supply chains for apparel and textiles can be a fundamental tool that can improve textile value chains. (Chen, 2023)

3.2.1 Blockchain definition

Blockchain can be described as “a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network. An asset can be tangible or intangible. Virtually anything of value can be tracked and traded on a blockchain network, reducing risk and cutting costs for all involved.” (Magdi ElMessiry and Adel ElMessiry, 2018)

The blockchain comprises different blocks that make a chain and each block has its set of transactions where all the information, inherently auditable, unchangeable, and open, is stored. An immutable ledger means that the content of each block cannot be erased or changed once it has been written. (Staafgard, 2024)

Significant illegal trades, unethical manufacturing practices, and vulnerable supply chains have placed industries under considerable pressure from customers and governments to adopt sustainable production methods.

More and more industries are expected to be transparent and be able to share more about their operations and internal organization. Some of the main problems, in the textile and

clothing industry, are unpredictable customer demands, growing competition, and product returns and imitations.

Because of its opaque supply networks, it is also heavily criticized for using harmful materials and unethical labor methods. The need for quick action has been further increased by recent disastrous events.

To solve these issues related to the textile and clothing supply chains, technology has provided a perfect solution with the creation of supply chain traceability and the blockchain system.

Traceability, as defined in the United Nations Global Compact and Business for Social Responsibility (2014) is “the ability to identify and trace the history, distribution, location and application of products, parts, and materials, to ensure the reliability of sustainability claims, in the areas of human rights, labor (including health and safety), the environment and anti-corruption”.

Because blockchain technology creates safe and unchangeable information paths, it has emerged as an attractive option for supply chain traceability. Through the use of this technology, safe information exchange, supply chain transparency, operation control, and product quality monitoring are made possible. It is difficult to build trust amongst widely distributed supply chain partners, and third-party auditors' function is frequently called into doubt. With the current technologies, accurate information sharing over extended periods is challenging. (Magdi ElMessiry and Adel ElMessiry, 2018)

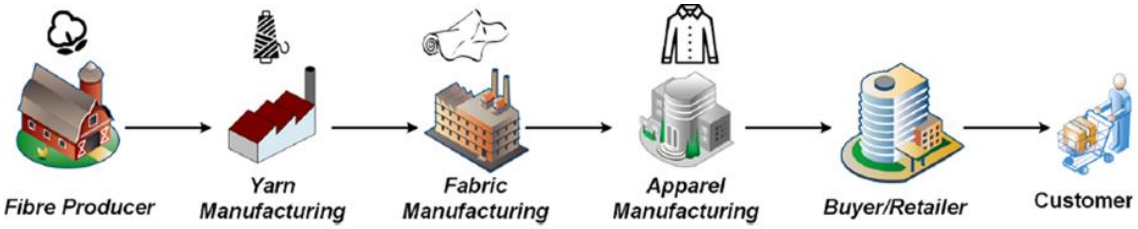
In the textile industry, many manufacturers gave up on quality by supplying raw materials from low-cost players to be more cost-effective and competitive in such a global market. The inefficiency in the monitoring systems causes the cost of poor quality to be 14% of sales for the apparel industry, compared to the other industries (where the percentage is half of it). Thus, there is an urgent need to monitor the different processes inside the textile industry to obtain the best possible results, in terms of quality and profitability.

Blockchain’s decentralized network structure and data immutability can provide better visibility and build technology-based trust among stakeholders.

3.2.2 Background of the Apparel Industry

As already mentioned, the fashion industry supply chain can be really long and present internationally. It starts with fiber production, which can be natural (like cotton) or made industrially (for example polyester). These fibers become then yarn, thanks to the yarn-manufacturing processes, and are later made into fabric through weaving, knitting, or nonwoven processes. The next phase is called stitching, which refers to the mass production of clothes and garments using highly specialized machines. Figure 3 represents all the different steps within the textile value chain.

Figure 3, The textile value chain



Source: (Agrawal et al., 2021)

It is possible to divide the textile supply chain between primary and secondary activities.

Primary activities include:

- Inbound logistics. It comprises the relationships with suppliers and the activities related to them, such as collaboration and the supply of raw materials.
- Operations. They include all the activities related to the transformation of raw materials into the final products.
- Outbound logistics. They involve the after-production activities, such as collection, storing, and distribution of outputs.
- Marketing and sales. Include all the activities related to the promotion and sale of the products.

Secondary activities include:

- Procurement, Human Resource Management, Technological development, Infrastructure.

Garments are defined inside the dictionary as “an article of clothing”, however, from a different point of view, it could be defined as the end product of a long value chain made of many different steps and long processes. The end quality is given by the initial materials and by the different manufacturing processes involved.

Fashion brands have the task of identifying upstream partners and suppliers and they base their decisions on evaluating factors such as the cost of manufacturing in different locations, suppliers’ reliability, and consumer preferences. (Chen, 2023)

Given the complexity of the textile value chain and its spread over numerous different geographic locations, the focal firms (which stand for fashion brands and retailers) find it difficult to monitor the sustainability issues inside the supply chain and keep track of all the different players involved. This undefined information base permits to upstream suppliers to take advantage of information asymmetry and adopt opportunistic practices that go in their favor, reducing costs and maximizing profits. (Magdi ElMessiry and Adel ElMessiry, 2018)

Adoption of blockchain technology may be the solution to these issues to make transparent all the different parts of the value chain and make communication inside smoother and more honest.

3.2.3 Opportunities for the Textile industry and value chain

There are many different occasions for the application of this technology in the fashion industry and it could be strictly related to sustainability. Blockchain designed for business and supply chain management has more privacy and restricted access compared to public applications. Based on the accessibility level, each partner has different possibilities of seeing and accessing information and, in this way, can maintain competitiveness without sharing important strategies and business-related details. This structure can guarantee visibility and transparency and enable the implementation of all the different directives and regulations, related especially to sustainability.

Blockchain technology is particularly beneficial for fashion supply chains in many ways: in boosting production authentication, and facilitating and improving demand forecasting. The adoption of blockchain technology allows supply chain participants to obtain the most recent transaction data and transfer information to a third party. Blockchain verifies the origin and authenticity of the products, which is important in confirming their value, particularly for luxury items, such as diamonds, and establishes reliability in supply networks and can be used as a tool to gather data for evaluating working conditions to ensure the procurement of ethical materials. (Agrawal et al., 2021)

3.2.4 Blockchain Technology in Europe

Regarding sustainability issues, blockchain can create many benefits, especially in Europe due to the environmental impacts that it has. The TRICK project was implemented and founded by the European Union in 2021 to improve firms' performance regarding sustainability goals and motivate them towards a circular economy thanks to the adoption of blockchain technology.

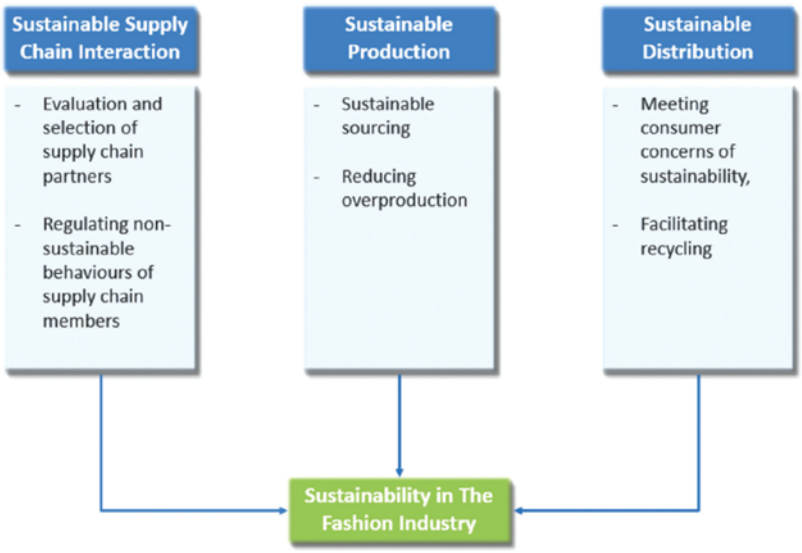
The project aim was to promote sustainability through the entire fashion value chain, comprising sourcing, production, and consumption thanks to the blockchain-based platform designed by the Quadrans Foundation. “Quadrans protocol is designed to reduce the environmental impact by enabling an efficient use of network resources and achieving consensus in a sustainable way” (Quadrans.io).

In this way, brands and firms in the textile and apparel sector can reach higher levels of environmental and social sustainability achieving a more circular business model.

3.3 Sustainability and Blockchain

A study conducted to show the main areas of adoption of blockchain for sustainability identified the main areas where this technology can help improve the environmental and social impact from the choice of the suppliers to the recycling process. (Chen, 2023)

Figure 4, Blockchain and sustainability



Source: (Chen, 2023)

Blockchain technology can have a direct role in the choice process of suppliers as it provides transparent information and helps companies keep track of the sustainability commitment of each supply chain member. Furthermore, it plays an important role in attesting primary material suppliers, the dyeing processes, and certified garment producers to ensure sustainable operations. (Agrawal et al., 2021)

Once the decision has been made, it helps to connect with all the supply chain actors and create a framework to control their actions and behaviors, preventing excessive emissions and improving wastewater and overall impact. IoT technology helps to protect all the data when entered into the system and enables the exchange to all the participants, so they can have full visibility of what is going on and how much impact every step of the chain produces.

Additionally, blockchain technology can help integrate the ERP systems of all the different players in the supply chain to reduce overproduction and synchronize market demand and upstream availability of products. In such a way, coordination is highly improved and sustainable production can be encouraged. (Gautam, 2023)

Consumers can also have plenty of benefits because they are provided with important information about sustainability and the history of what they are buying and be sure that they are purchasing something valuable and authentic.

Finally, this technology can increase the benefits of recycling and reuse of textile products. It allows clothes and materials, once they are no longer in use, to be easily traced and evaluated according to their state. Once this has been done, they can be used as second-hand clothes, or sent to disposal or sorting centres where they are transformed into different products. In this way, waste is reduced and once again sustainability comes in the first place.

Chapter 4. Methodologies for the Case Studies

As said in the introduction, the research is to explore the different impacts that technology and sustainability have on different types of textile industry value chains.

The aim is to discover how emerging technologies and an increasing commitment to sustainable practices can have a different impact depending on the type of textile value chains, and assess the potential synergies between these two forces.

To support the literature review and deepen the topics studied, I've searched for innovative companies in the sector that could enrich my research and support the thesis.

I selected three different companies with three different types of value chains for the in-depth study of my research: The Marzotto Group, Elbec, and Rifò.

Each one gave me a different perspective on how it is possible to respond to uncertainty and changes in the textile industry, providing a valuable contribution to my research.

To complement my analysis, I've searched for a blockchain technology provider, that could provide me with a deeper and broader picture of the phenomenon. Thus, the fourth case was the analysis of the company Textilechain.

The research was carried out following the same interview protocol, reported in the Appendix.

I asked each company similar questions aiming at drawing general conclusions to find similarities and differences using key thematic categories. This has helped me to understand the key aspects.

Each interview has been recorded and transcribed to allow a better analysis and comparison of the cases.

I then integrated the data provided in the interviews with data from the company's reports, to be as accurate and detailed as possible.

After that, I transcribed all the interviews finding all the common and different patterns. This helped me to put all the data together and understand better the issue, making me discover how many differences or similarities there are in each case.

However, I acknowledge that there might be some limitations regarding the limited number of case studies and the selection bias. Even though the cases show in-depth insights, they may not generalize the situation of the entire textile industry and they may not represent the full differences within the fashion sector.

Chapter 5. The analysis of the case studies

Shifts and transformations in the textile value chains, the adoption of new technologies such as the blockchain, and the commitment towards sustainability, are all tied together and give strength to each other, creating benefits both for consumers and for the environment. The connecting theme is an innovation process that merges research, creativity, new technologies, and sustainability.

To understand deeply what I have discovered and explored through my research and literature analysis, I decided to look for companies and brands that could give me a more complete vision of the topics in question.

To keep up with the times, it has proven necessary to reinvent one's value chains and find alternative solutions allowing different realities to adapt.

Many innovations vary from investing in new technologies, which can be applied differently and create various advantages along the entire supply chain.

It has been possible to see how digitalization represents a real opportunity for any type of industry, and for the textile one too.

On the other hand, there is an ever-increasing focus on sustainability, and being unsustainable is no longer a possible option. Now it is essential to go in this direction.

In the cases I have analysed, which include both large companies with a long supply chain, and newer companies that instead have a short supply chain, it has been possible to notice how innovations in the textile sector are represented both by investment in new technologies and by investment in more sustainable practices.

There are even examples of how these two aspects can blend to be supportive and boost the capacity to reach new goals and objectives.

With innovative value chains and fabrics, which all have the objective of responding to the ever-increasing uncertainties of the Italian and global market, it is possible to cope with market challenges and bring to the market new items that are more sustainable and include better and ethical practices.

It was possible to notice some differences depending on the length of the value chain. For longer and more complex supply chains, investing in technology and digitalization is something more common because new technology can strongly improve the communication process and collaboration along the value chain and, at the same time, make impellent the urge to invest in technologies, such as the blockchain, that can help improve their traceability and transparency process.

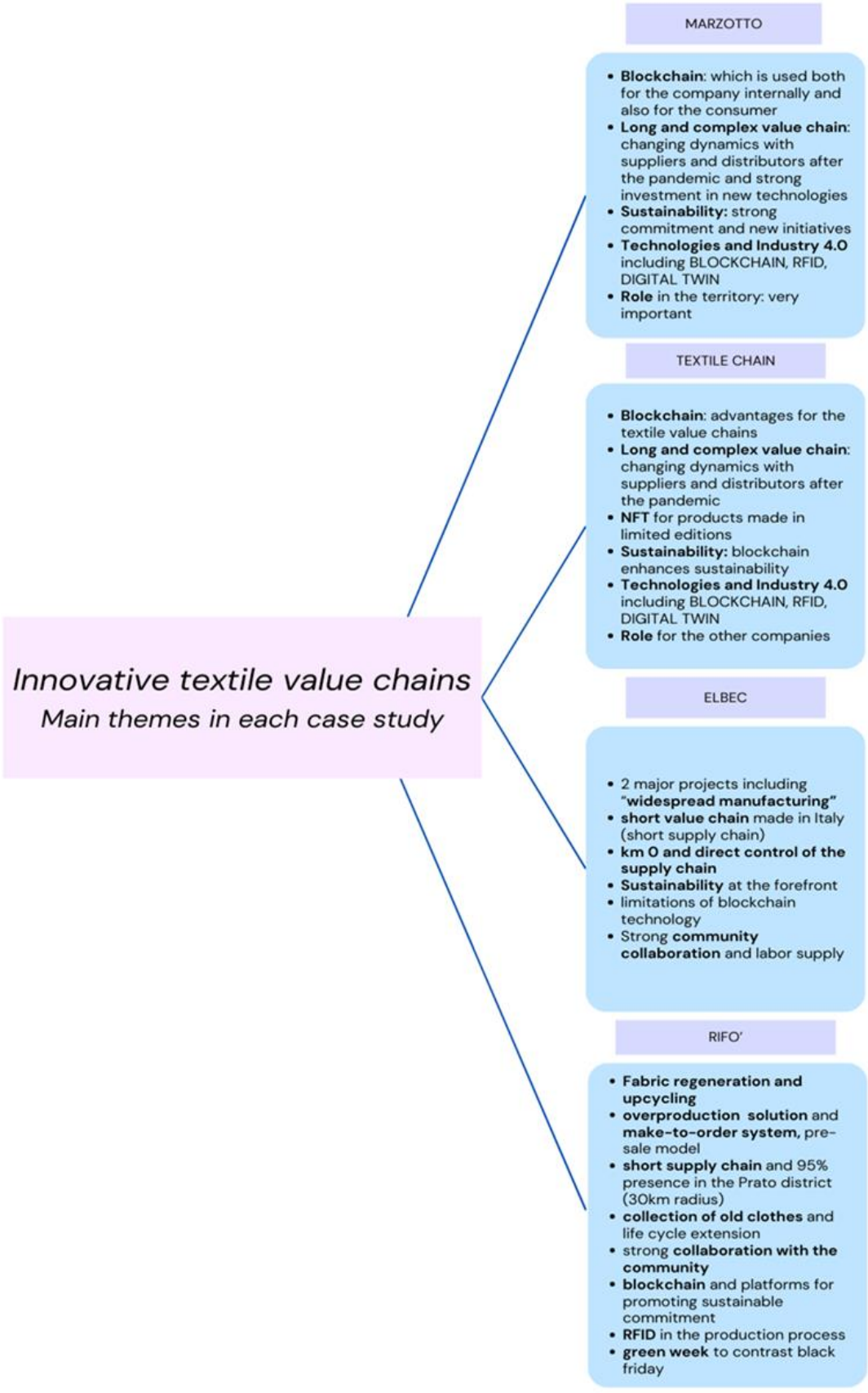
This is something not always easy to do, as there are smaller brands where these types of investments are not feasible. Even though there are all the assumptions necessary to make this kind of step, the costs and the time of implementation can represent a big barrier.

During the research, problems related to marketing and greenwashing have emerged too and such issues can be improved by the use of some technologies.

Other limitations are given by the lack of standardization and specific regulations that can make all the brands aligned on what specifically they need to do. However, every state and body has its rules and it might be difficult to align accordingly.

Other important innovations related to the ending of a product's lifecycle, are recycling and upcycling, which for some brands is at the core of their operations. The next Figure 5 shows the key thematic categories analysed and researched in each case, providing a broad picture of the characteristics and aspects discussed in each case.

Figure 5, The key thematic categories



Source: own elaboration

5.1 Presentation of the Italian case studies and their value chains

I have analyzed and interviewed four companies: the Marzotto Group, Elbec, TextileChain, and Rifò. These realities are different from each other and have different types of strengths.

Thanks to the variety of the cases I could highlight different aspects and had the opportunity to understand more points of view, which provided me with a clear picture of what they are doing and made me see what themes of the literature I've discussed above, are possible to be related to the cases.

Marzotto Group

Figure 6, Marzotto Group logo

Source: (Marzotto Group, 2022)

The Marzotto group has a long history, which started in 1836, with the foundation of a small textile mill and the production of worsted yarn in Valdagno, in the province of Vicenza.

During the 20th century, the company expanded in the Italian market producing garments, yarn, and fabrics. In the following years, the fabrics grew a lot through the acquisitions of iconic brands and meaningful commercial deals with important clothing brands. (Marzotto Group, 2022)

Marzotto has now become a key international player in the textile industry and represents a "company network", comprising numerous prestigious brands and functioning as a hub in the long textile supply chain. Its production includes the clothing and cotton sectors, the knitwear wool yarns, and the linen yarns and silk sectors. (Marzottogroup.it, 2024)

The Marzotto Group currently has 12 brands, 10 plants situated both in Italy and abroad (Czech Republic, Lithuania, and Tunisia), and a worldwide commercial network, as shown in Figure 7.

Figure 7, Marzotto worldwide commercial network

Source: (Marzotto Group, 2022)

In 2022, they sold around 24,600 km of fabric and 5300 tons of yarn. They account for around 3894 human resources and 10 production facilities in Italy and 5 abroad. (Marzottogroup.it, 2024)

In 2022, they had 369.5 million euros in turnover and 12 trademarks recognized worldwide.

Marzotto Group looks after the entire supply chain to make sure that the entire process, from the raw materials to the final production, reaches high-quality standards with the implementation of an end-to-end supply chain model.

The company is a key international player in the textile industry and comprises prestigious brands in Italy and around the world, thanks to its historical know-how and the quality of its products.

The mission is “to be a full-service textile company that can coordinate a wide range of skills and processes and optimize its know-how along the entire textile supply chain.”(Marzotto Group, 2022)

Elbec

Figure 8, Elbec logo

Source: (Elbec, 2024)

Elbec was founded in 2015 by Federico Sordini and is a well-known brand for its Merino wool socks and outdoor sportswear production.

The company was born in the Dolomites, in "Val Pettorina." It produces technical and natural products intended to be entirely sustainable, from the raw materials to the final products. The concept of sustainability is fundamental and represents its essence.

Elbec makes products from high-quality materials and maintains rigorous attention to sustainability and environmental well-being throughout the entire value chain.

"They strive to promote a relationship with the consumer on honesty and transparency". (Elbec, 2024)

Their entire manufacturing is based in Italy because they still believe that is possible to have a product made in Italy, despite the difficulties present nowadays in the textile marketplace.

They started with the aim of protecting and fighting for environmental preservation and sustainability because they believed in these issues and the prevention of cruel practices such as "mulesing"

The Merino wool they use has a mulesing-free certification, meaning that the sheep have not been mutilated and are not subjected to pesticide dips.

Even though the situation is in constant evolution nowadays, they started 10 years ago and they have two different productions. One more industrial where they use Merino wool, coming from New Zealand to produce their socks.

Then they started a second project in 2018, called “Manifattura Diffusa” a widespread manufacturing project, which represents a short supply chain, with the production based entirely in Italy, everything hand-made, everything produced with Italian wool. Thus, they are two separate projects, very different from each other.

The aim was to be able to control the entire short supply chain with the internationalization of all the processes, from the breeding of the sheep to the final Italian zero-kilometer products.

All the wool comes from small animal husbandry, located in areas above 1500 meters, with maximum respect for animals and the environment.

The project was born with the aim of including people from the valley of the Dolomites in the production process allowing anyone who knows how to crochet and knit to participate and work from home.

Rifò

Figure 9, Rifò logo

Source: (Rifò, 2023)

Rifò is an Italian brand that was born in 2017 in Prato, as a response to the overproduction issue in the clothing industry.

The founder Niccolò Cipriani, after two years of working in Vietnam, decided to go back to his city and start an innovative project based on textile recycling. The name Rifò is, in fact, a Tuscan inflection of the verb “rifare”, which means remake and redo.

Their philosophy is based on Circular Fashion and, thanks to the recycling of fabrics (both pre-consumer recycled and post-consumer recycled), they create high-quality products, recycled in Prato from old and discarded clothes.

The entire process starts with the collection and selection of old clothes and textile waste and then there is the transformation part that involves the production of new yarn, later woven into new garments of high quality.

The yarn and the fabric suppliers are located in Italy, especially in the textile district of Prato, creating local craftsmanship in a range of 30km, as it is possible to see in figure 10.

Figure 10, Rifò suppliers

Source: (Rifò, 2023)

From the beginning, they decided to make local production the priority to achieve a better sustainability commitment, reduce the overall environmental impact, and support the local economy.

In 2023, Rifò produced a total of 72.269 clothes and accessories, recycling 14.1 tons of textile fibers, and reached 335 resellers all over the world.

Their clothes are now sold at transparent prices and under a pre-order model to ensure the exact response to consumers' demand, avoiding overconsumption.

TextileChain

Figure 11, Textilechain logo

Source: (Foodchain Spa, 2019)

Textilechain was born as the spin-off of the company FoodChain Spa in 2019.

The company started as an innovative business to promote transparency and traceability in the food supply chain and after the founders Davide Costa and Marco Vitale witnessed an increasing international interest in their traceability model, they decided to enter the textile sector.

The project of Textilechain was developed to trace textile value chains thanks to the exploitation of blockchain Quadrans technology. (Foodchain Spa, 2019)

Foodchain identified the opportunity to apply its knowledge, experience, and technology to deal with similar issues compared to the food industry, like textile authenticity and ethical working conditions.

There were already present some solutions in the market, but Foodchain saw the chance to significantly improve the efficiency and security of existing solutions thanks to its blockchain technology, launching a project called “Textilechain”.

The fashion and textile industries have similar complexities to the ones of the agri-food industry, with global value chains that comprise many different actors and processes. Furthermore, the counterfeit problem is particularly relevant in this industry. Blockchain, with its ability to create immutable and verifiable ledgers, offers a powerful and effective solution to guarantee products’ authenticity and fight against counterfeiting, thus protecting brands and consumers.

It aims to help companies interact in a better and faster way and make them exploit all the possible opportunities offered by digitalization and new technologies diffusion. Textilechain thanks to its technology, allows companies and brands to trace their value chains and offer traceable and verifiable products to consumers.

5.2 Analysis and comparison of the cases

5.2.1 Differences in the value chains

As highlighted through the literature study, global value chains are significantly changing and the textile sector has proven to be particularly affected by both technological innovations and the growing attention towards sustainability.

I chose to interview companies with different types of value chains, which allowed me to see the different impacts that the above-mentioned issues have had in each case and to go deeper in discovering how the choices regarding sustainability and technology issues can vary.

Depending on the length and the type of value chain, the needs of entrepreneurs can significantly change and the priorities of the company can vary. It all obviously depends on the different costs, the number of people to manage as well as the different suppliers and distributors, and finally the very essence of the brand.

Marzotto and the long value chain

The first case analyzed, namely Marzotto Wool Manufacturing, has a very long value chain that is spread worldwide. It starts with the upstream production processes, including the procurement of raw materials, and it passes through the direct phase in control of the company, which includes the manufacture and production of yarns and fabrics. It ends in the downstream phase of the production process and includes the distribution, sales, and use of the final products.

The group has many different suppliers of raw materials that are located in many different countries of the world, such as Italy, the Czech Republic, Australia, Germany, South Africa, Argentina, and China. (Marzotto Group, 2022)

The Marzotto Group has also many different customers, which include very important clothing brands in the luxury division of the fashion sector, distributed worldwide.

In the city of Valdagno, they primarily focus on wool. However, they also produce cotton and linen in other fabrics located in different sites. Despite the differences in the production methods, the process and the logic behind it remain almost the same.

To make a wool fabric, which accounts for 95 percent of their turnover, the process starts with thread, therefore weft thread and warp thread. The thread is made from the raw material, which is the wool that comes from the sheep and is known as greasy wool.

To be able to get to the wire instead, it is necessary to go through an intermediate phase, which includes cleaning the wool, to remove soil, vegetables, and other impurities; once the cleaning is done, the wool fibers are carded to be aligned and made easier to handle for spinning. When the carding is done, which is the phase in textile production that includes the separation and organization of fibers, the wool is ready to be spun into yarn.

This entire process starts with the wool purchase from sheep and then there is the combing, spinning, and weaving of the wool. Their work and involvement in the Marzotto wool manufacturing stops at this point.

Their clients are spread worldwide and present in many different countries, including very prestigious brands. Every known brand in the clothing industry has been probably their client or it is now. Even with the knitwear sector, through the Lab division, they are present in the final clothes and products of many brands.

The Group thus presents a very long and complex value chain that needs to be managed efficiently and consciously, with the exploitation of technological opportunities both to improve all production phases and then the relationship with suppliers and customers, and certainly to obtain better results in the area of sustainability.

Considering the geopolitical situation and the impact of the Pandemic, the company has been undergoing some changes and adaptations because of the increasing delays and value chain disruptions. However, they managed efficiently the situation relying on their historical experience and know-how.

Elbec and the short value chain

On the contrary of the Marzotto Group, the company Elbec has a short value chain.

Thanks to their project “Manifattura Diffusa”, they have direct control of the value chain making products with a particular focus on the quality of the materials, and they commit to environmentally friendly practices in every phase of production.

The short supply chain has the production based entirely in Italy, using rigorously Italian wool coming from the region of Abruzzo, while the production is based in the Dolomites.

They believe that having an Italian zero-kilometre product can enhance their value and, in the meantime, make the brand reach important sustainable goals.

They also help the community by involving everyone who knows how to crochet and wave to participate in the project and work from home, creating important pieces of garments that are entirely sustainable and consciously made.

This value chain, compared to the first one, has different types of needs. Technology can take on different nuances and be more difficult to apply. On the other hand, having direct control of the supply chain and using Italian farms, based on very small realities, can significantly increase the commitment to a less polluted environment and lower impacts.

Rifò and the circular value chain

The brand Rifò has a short circular value chain with a circular business model. Their circular supply chain is located within 30 km of their office in the textile district of Prato. They have in common with Elbec the local production, which was primarily adopted to reduce the environmental impacts of transportation and exploit the value created by local textile traditions and respond to the increasing issues in the textile industry, which generate a huge amount of waste and emissions.

The circularity of the value chain is achieved through the reuse and recycling of materials into durable and ethical products.

They use textile materials containing recycled fibers, which include cashmere, wool, cotton, silk, and denim coming predominantly from suppliers based in the textile district of Prato, as shown in Figure 12.

Figure 12, The origin of the materials used

ORIGIN	MATERIAL
Prato, Italy	Recycled cashmere
Prato, Italy	Light cashmere
Prato, Italy	Recycled wool
Prato, Italy	Recycled wool fabric
Alicante, Spain	Recycled & organic cotton
Biella, Italy	Recycled & virgin cotton
Prato, Italy	Recycled denim
Prato, Italy	Recycled & organic denim seatshirt
Biella, Italy	Recycled silk

Source: (Rifo S.r.l., 2023)

This type of value chain allows to achieve extraordinary goals in terms of sustainability. The life cycle of clothes is extended, reducing significantly the amount of textile waste (which very often ends up discarded and abandoned in foreign countries, causing pollution to the environment and the population) and moderating the overall impacts.

5.2.2Digitalization and the Impact on the Value Chains of the Selected Cases

In the textile industry, the digitalization process and the availability of new technologies have impacted global value chains and made companies rethink their businesses.

New technologies are presented as fundamental tools to be integrated into their value chains to respond to the continuous changes and uncertainties of the market. However, their role can significantly change based on the type of company and the length of its value chain.

In a long and complex value chain, such as that of Marzotto, technology can come to support improving communication and collaboration with suppliers and customers even in different parts of the world. Integrating technologies such as blockchain, digital twins and artificial intelligence becomes a real strength for the company, creating further improvements in the production process, and in the design process. Furthermore, technology and sustainability can merge creating extraordinary opportunities to safeguard our planet and contribute positively to an increasingly green and more aware economy.

Things change when we talk about brands such as Elbec, which has a short supply chain, for which technology will play a different role, creating opportunities of a different type. Here too, traceability has a strong importance, and technologies such as blockchain can come to support to further enhance the origin and production chain of the product. Optimizing production processes on a small scale and reducing waste and emissions are two other fundamental aspects.

In the third case of Rifò, where the keyword is circularity, technology can always help with the transparency and traceability of all the different phases and can also help the

separation of the fibers that make up the materials, as well as optimizing the recycling process.

Marzotto and the impact of digitalization on its value chain

- **Improved communication with stakeholders (including suppliers, clients, and customers), driven by new information systems.**

In recent years, new technology developments have certainly improved relationships and communication with distributors and suppliers around the globe, but not all the issues have been solved, as the recent events have deeply tested global value chain resilience.

When talking about customer relations, there has been a huge improvement in the communication and exchange process among employees, departments, and external stakeholders thanks to the adoption and integration of new information systems. The company stated that there has been a huge improvement in this regard and that the data exchange has become more fluid and efficient making management with customers easier.

Even though the Pandemic has harmed the efficiency of supplier relationships, causing serious delays and logistical problems, new technologies have created numerous opportunities. Their focus has remained to continue improving these processes, adapt to global challenges, and make the best of the available technological innovations.

As Marzotto has a long and complex value chain, digitalization has improved communication and collaboration among suppliers and clients, enabling big clients to see all the fabric and the pieces and whether they have already been placed in the warehouse or shipped.

Their clients can see in every single moment the deliveries and make real-time requests. Years ago, this was not possible as everything was done by phone calls and it took a lot of time to gather the necessary information. However, now this exchange of data, information and updates has become much smoother and faster.

- **Improvement of the design process with CAD modelling and Digital Twin technology**

Even the design process had some significant improvements, as the clients now can have a proper feeling of the textiles and pieces thanks to the information system that once

would have been almost impossible and would have required producing and sending physical samples. The clients would receive the samples, review them, and then discuss them. The majority of this process is conducted online now.

The Marzotto Group launched a project 5 years ago in collaboration with Hugo Boss.

Essentially, when they create a new garment or fabric for a season, twice a year trends and fabrics are presented. However, when there are clients with specific and exclusive requests, there has been a real improvement in the entire process that involved multiple physical trials, as before various samples had to be produced and sent before the choice was made.

Thanks to the development of new textile CAD modelling systems and garment CAD systems, manufacturers are now able to model the garment in 3D and create a digital twin of the product.

This computer-aided design makes it possible to reproduce digitally 2D drawings and 3D models of real-world products, before the production process.

It becomes possible to model clothes in 3D and simulate the stitching of various panels. Clients can then see the final tailored model and overlay the image of the fabric on it.

This image is so much more than a photo; it includes the roughness, transparency, tri-dimensional shape of the weave, colour, thickness, drape, and bend angle. When it is overlaid on the virtual mannequin, the virtual body, the virtual garments fall perfectly with the weight and curves of the arm and conform to the shape of the body, as it is real. It is almost impossible to distinguish the photo of the virtual and the actual garment and the first one seems more realistic sometimes.

In this way, it is not necessary to send the fabric in the real world to their clients. They receive the data and the surface details regarding the clothes' characteristics to apply to the virtual prototype so then they can make changes and tell what has to be changed or improved.

The company can modify it in the system, send it back, and within three days, it's done. They've defined exactly what the client wants, and then is possible to continue with the production phase.

Previously, this process would take a month, with back-and-forth sending of physical samples, making garments, and sending them back and forth. It's incredible how much this new technology has streamlined the process. However, many still rely on physical paper prints and fabric samples, making it hard to move away from traditional methods.

Digital Twin technology helped them to enhance virtual prototyping, accelerating the design process and creating personalized garments to satisfy customer demands.

It helped them with real-time monitoring and improved quality and finally the achievement of more sustainable goals (thanks to the reduction in water, energy, and material consumption) and waste minimization.

Physical and tactical experience remains a fundamental part of the textile industry. Having the ability to touch the fabric with your own hands is of fundamental importance and represents a more satisfying way to choose fabrics. It would be almost impossible to eliminate this experience and replace it with some new technology.

So, there is the technology that helps you, but an emotional part remains linked to the five classic senses. Specifically, it is precisely their type of product that has these characteristics or limits, because for other simpler products, such as t-shirts with prints or things like that, digital represents itself a perfect way to replace completely the physical garment for the entire design and simulation phase and so on.

- **Automation, digital integration, and real-time tracking with RFID technology**

Digitalization had a huge impact on machine automation and data integration. Their machines have been integrated with CAD/CAM systems, making the transfer of design parameters faster and easier. Industry 4.0 has pushed innovation in this regard creating efficient and accurate machines, without the need for human intervention. This also reduced significantly human errors, improving efficiency and overall productivity.

They have some types of machines, typically weaving looms, which are the machines that intertwine the warp and weft to build the fabric. These Looms can receive instructions directly from the CAD, where they design the models. Thus, instead of sitting and manually inserting the different parameters on the machine, which is a long process with a lot of different data requested, they can transfer all of the necessary settings, passed from the CAD system, which is the CAM file, directly to the loom. In this way, the operator simply

types in the name of the item to be made and the loom receives the weave and sets itself up automatically.

These machines can perform different tasks, sometimes simpler, such as setting only two or three parameters, such as speed and temperature, and other times more complex with a greater amount of data elaboration.

Furthermore, these machines are now able to track and report their activities and all the steps in real-time, improving the production process and saving a lot of human intervention and time.

They can report what particular piece of fabric they have been processing at a certain time and day compared to before when it was necessary to put a stamp on a piece of paper to show it was done. Namely, it provides a lot of details and information that are then collected and analyzed. This can serve as a retrospective analysis to report if there was an issue and see if something particular has happened, or provide statistical analysis and keep track of the quality and the production process.

With specific tools, a whole hardware and software solution has been implemented for the automatic detection of fabric progress and advancement, which they identify as pieces, whether they are smaller pieces or larger rolls.

Therefore, the manual intervention of the person is no longer necessary, but everything is detected with specific chips. Each chip has the name and the serial number of the single piece that the system already knows and automatically creates a depository. In this depository, which could be considered similar to a big data system, they track each number and all the advancements steps within the finishing department. This department is quite complex, as it involves a processing of more than 20 steps and involves 20 different machines.

Each piece of fabric, whether it is 70 meters or 210 meters long, has a heat-sealed label under which there is a mini RFID chip. This chip records the serial number of the fabric, which then enters the machine where antennas can read it and in real time process and send the data to the system.

- **Transparency and traceability through blockchain technology**

Blockchain is a highly adopted technology in many different industries especially in the textile one. The Marzotto group has adopted this technology too and is using it both in the production process and then for the outside stakeholders.

1. Production process and traceability

They have a series of codes, which are transferred from one phase to another, organized in blocks. After receiving a batch of wool that is already combed, washed, and ready for dyeing, they assign it a number and they are able to date back to where this batch came from, which farm, and which facility it was processed and combed in. Then the dyeing process is done and the batch assumes another code. This batch of wool was used to produce various dyeing batches, which then generated different spinning batches, finally generating several different fabrics.

These fabrics are then utilized to manufacture pieces that are transferred to the customer, each recognized by a unique serial number. So, at each phase, new codes are added.

This system allows for tracking every phase of production and ensures the quality and sustainability of the final product.

Furthermore, if there is potentially any type of issue, the company can trace back the process, find out the cause of the problem, and adjust it accordingly.

For every selected fabric, it is possible to trace back the wool and spinning batches used as well as the processing details. Sometimes this operation is easier and straightforward, but other times could be challenging, as many different systems and cross-referencing codes are involved.

Thus, this tracking system is essential and useful for the internal processes within the company, not just for the final consumer.

2. Blockchain and Improvement in Traceability

The Company uses blockchain mainly because of its unique features. This technology can guarantee the transparency and verifiability of their products since every piece of information added at each step is immutable and guaranteed. Blockchain provides this

type of security and, when there are many different processing phases and types of fabric and operational processes involved, it can become a truly valuable tool.

Thus, having a blockchain that supports these data with a validation system ensures that the information is accurate and trustworthy. However, blockchain is simply a way of recording information and if you don't know what to write, blockchain becomes useless.

In the textile industry, rather than talking about blockchain, the focus should be on traceability. Companies are interested in tracking the origin and components of every material and fabric they sell. This is crucial not only for their records and internal management but also because certification requirements are increasingly stringent. They are the first to benefit from tracking all this information.

Furthermore, what has emerged, is the fact that the final customers may not be that interested in knowing the exact origin of the fabrics, but rather to have the certainty that every phase was conducted under sustainable and conscious standards.

3. Lack of standardization

Another aspect that was highlighted about blockchain, is the lack of standardization and homogeneous certifications in every country. This could represent a problem, especially for companies with long and complex value chains present in many different countries.

There isn't a universal system for blockchain or for tracing and certifying information and there exist various initiatives and standards, which aren't global or recognized by everyone. Different regions and sectors have their standards for various fibers like cotton, wool, and others. It's a very complex and intricate world, lacking clear and defined legislation, at least at the European level, which adds to the confusion.

Every client, and thus every country, launches their initiatives. Some are more structured, while others are created entirely ad hoc. For instance, France has established a system that applies within its borders. They have created a portal called "Fairly Made", and in principle, all French clients refer to that portal.

Other countries are not following the same path. The issue is the lack of clear regulation, at least at the European level. We live in a global world, and this aspect should be addressed by early 2027.

Elbec and the impact of digitalization on a short textile value chain

As mentioned before, Elbec has, under the project "Manifattura Diffusa", a short supply chain, where new technologies have a different type of impact and are meaningful for different reasons, compared to companies with longer value chains.

- **Transparency and blockchain technology**

In its case, where production is local and the procurement of raw materials comes from local shepherds, blockchain technology could have such positive impacts to prove the traceability and transparency of sustainable products.

Their products come from a supply chain that is entirely controlled and sustainable, with particular attention to the environment and sustainability in every phase of the value chain. From the first phase of supply, up to the final product, the kilometers of transport are substantially reduced, as well as the consumption of water and energy.

However, the company discusses about potential limitations of blockchain, particularly referring to the manipulation of information without verification by a third party and the costs.

For small businesses, this can represent an obstacle because of the high costs of adoption and implementation. Elbec has still not adopted blockchain technology, even though the huge potential and the benefits it could have.

The adoption of this technology could range from 5000 to 6000 euros per product and while the costs could decrease for the subsequent products, they are still very high for a reality like theirs. In this way what happens? On one side, larger companies are ahead as they can afford such expensive operations, which is something usual with European policy, and, on the other side, these costly operations represent a huge disadvantage for small businesses.

The analysis of this case shows how certifications and digitalization can be important tools to promote transparency and traceability of a product. At the same time, they can create obstacles for smaller companies with a shorter supply chain, due to the lack of affordable prices. Certified products can certainly be a way to approach the topic of sustainability. However, they do not always represent the real situation due to high transport costs and environmental impact.

Therefore, digitalization certainly offers great opportunities to demonstrate the real history of a dress, but it is not a given that even the most sustainable supply chains can use and obtain them.

Further digital tools to be implemented could represent significant tools could help quantify and track CO2 emissions, energy and water consumption, and the origin of materials. They could also increase efficiency in local production, manage inventories, and optimize forecast demand.

Rifò and the impact of digitalization on its circular value chain

Rifò's circular value chain prioritizes transparency and traceability throughout the entire value chain. They collect fabric waste and used clothes, thanks to their take-back service, and make them part of the recycling process.

- **DPP (Digital Password Passport)**

They believe that innovation comes not only from technological advancements, even though it has a huge importance for guaranteeing traceability and sustainability within fashion supply chains.

They have incorporated a DPP (Digital Password Passport) solution making information about their best-selling products transparent and available. Thanks to the collaboration with BCome, "a pioneer in the application of intelligent methodologies for global sustainability management", they've integrated this system to make transparent data about environmental impact, adding a QR-Code on the label of these products.

The brand can exploit BCome methodology, which is always updated based on European Regulations, for the Life Cycle Assessment, Benchmark, and Traceability.

On every label, there is a QR-Code, that once scanned, shows the environmental impact of the garment indicating four different parameters. These include water scarcity, global warming, eutrophication, and abiotic depletion. These results are then compared to the other brands of the industry.

Even on their website, it is possible to view the major impacts of most of their garments and customers can consciously make the purchase, knowing exactly the entire value chain impact and history.

- **Open Supply Hub**

They are also using an online platform, which is called “Open Supply Hub”, built to collect supply chains data from users across sectors, and then make it available and easily searchable for anyone.

On this platform, everyone can search and find the map of their suppliers and learn more about them and their activities.

- **Blockchain**

To further improve this process and guarantee the transparency of their garments and clothes, they are planning to adopt blockchain technology. This will enable them to give a clear picture of the journey of each product and its production history, guaranteeing that the highest norms and standards have been respected in each different step. At the same time, they can demonstrate their commitment towards sustainability starting from the raw materials to the warehouse.

By January 2025, they are planning to implement this technology for their take-back service improving the tracking system of the garments’ collection. Rifò will collaborate with PaperTale Technologies, to create a traceability solution using blockchain technology. Those who donate their old garments will be able to have real-time information about their journey status, and whether they have been already recycled or not.

Digitalization and Textilechain Contribution

As blockchain technology provides, the company Textilechain has a deep knowledge of the industry and the true potential for textile companies. Blockchain technology emerged as a fundamental tool with an extensive potential for textile value chains, bringing advantages for every single actor involved in the process.

- **The advantages for the textile value chains highlighted by Textilechain**

Blockchain offers numerous advantages for the textile value chains. One of the most important is the higher transparency, because every phase of production, from the raw materials to the final product, is registered and can be verified independently.

The traceability allows firms to monitor and keep track of the entire journey of each product's component, guaranteeing that every part of the process is conducted respecting the quality standards and sustainability standards declared. This technology can provide greater security, reducing the risk of counterfeiting and fraud, because every transaction is registered in an immutable and verifiable manner. This not only protects the brands but increases trust among consumers for the products they purchase.

- **The advantages for the different actors involved in the textile value chains**

All the different participants of the value chain can perceive the main benefits of blockchain technology.

The suppliers can certify the provenance and the quality of their products, making information available for all the following actors of the chain.

The producers can better manage the supply chain, reducing risks related to the supply and improving the operating efficiency. The transparency provided by the blockchain can help identify and solve rapidly possible issues related to the supply chain.

Finally, the distributors can offer major transparency to their clients, allowing them to trace the product and verify its authenticity and ethics. This growing transparency can be translated into higher customer loyalty and competitive advantage in the market.

- **The main collaborations in the textile industry and its impacts**

Foodchain has collaborated with a few companies in the sector to optimize their value chain. The project Textilechain has witnessed the collaboration with the "Linificio e Canipificio Nazionale", which is part of the Marzotto Group, to trace the production of linen fabrics, improving its transparency and process reliability. This project has allowed to monitor every phase of linen production, from its cultivation to the transformation into fabric, guaranteeing that every step was documented and verifiable.

High fashion brands, like Gucci and Prada, acknowledge the blockchain value to ensure their products' authenticity and have already started using this technology to improve the traceability and sustainability of their supply and value chain.

Another important example is the NFT (Non-Fungible Token) adoption for limited edition products. The NFTs, which are unique tokens registered in the blockchain, can be used to certify the authenticity and the characteristics of their exclusive products. Some fashion brands have started releasing their NFTs related to their luxury, limited edition, products. These digital tokens ensure that every piece of garment is unique and unfalsifiable, offering proof of originality and complete traceability from the production to the final sale.

- **Other types of technologies for tracking textile value chains (IoT, RFID)**

Other than blockchain, other technologies such as IoT (Internet of Things), RFID (Radio Frequency Identification), and advanced systems for supply chain management are used to trace the textile value chain. All technologies that have been evolving simultaneously to the blockchain over the years can be integrated into solutions like their traceability platform.

Blockchain offers a higher level of security and immutability, which other technologies cannot. However, all of them can be integrated with the blockchain to further improve traceability and transparency.

IoT allows the collection of real-time data through sensors in the entire supply chain, monitoring parameters like temperature, humidity, and location. These data can be registered in the blockchain, creating an immutable and verifiable ledger of information.

RFID facilitates the identification and monitoring of the products, and the collected data can be integrated into the blockchain to guarantee security and immutability.

The management system of the supply chain coordinates and optimizes the logistic and production processes, integrating data from the sensors IoT, and RFID tags to provide a full observation of the supply chain. The adoption of the blockchain within these systems guarantees that all the information is secure and immutable, improving transparency and processes' reliability.

5.2.2 The impact of sustainability on the cases value chains

Marzotto and the impact of sustainability on its value chain

Marzotto Group is truly committed to controlling the entire value chain from raw materials to the disposing of production waste.

Over the years, the Marzotto group has demonstrated a growing commitment and responsibility towards the environment and people, adopting actions and conduct that could create a positive impact for each phase of the value chain. Renewable resources, natural and quality materials, and sustainable production processes are concrete examples of how the company is committed to fighting and preventing climate change. Controlling the entire value chain is of vital importance to ensure that all the regulations are respected and to guarantee sustainability right from the analysis of the initial fibers.

Their commitment was crowned by obtaining the ISO certifications and the B Corp certification in 2023, a very important certification that is awarded to companies with a particular devotion in terms of sustainability.

Over the years, the company has adopted a business model that promotes the responsible use of energy resources and investing in projects that could minimize consumption in the various production phases. They have installed photovoltaic systems in various production facilities and have increased the consumption of energy from renewable sources.

They also monitor greenhouse gas and pollutant emissions, following common international standards. Waste management, to support a circular economy, is a fundamental aspect of the company, which is committed to reducing the amount of waste produced and reusing materials in the production process when possible. In 2022, 45% of waste was recovered for recycling.

As for water consumption, the group has invested in technologies to reduce their consumption, also installing a system, reverse osmosis filtration, to recover significantly water resources.

The company has a strong commitment to sustainability throughout all the phases of the value chain, including suppliers and customers. Their goal is to become a service textile company, providing end-to-end service to its customers.

Their suppliers play an important role in their value chain too, as the procurement of raw materials is crucial and represents one of their strengths. Suppliers are chosen and assessed based on environmental, social, and economic parameters, including several certifications, checking always on human rights protection and the elimination of child and forced labour.

The selection of raw materials is one of the most important activities to ensure the quality and sustainability of their final products. The choice is consciously made, guaranteeing the protection of the environment and animal welfare, following the fundamental rights. The Group has adopted responsible procurement rules and 46% of materials purchased in 2022 were of renewable materials. It also focuses on the use and purchase of recycled materials to promote increasingly sustainable and responsible practices. (Sustainability Report 2022, Marzotto Group).

Elbec and its sustainable value chain

Short supply chains can represent an efficient solution to the increasing amount of issues related to sustainability and climate change in the fashion industry.

Elbec is a perfect example of how it is possible to achieve high goals and high-quality products, by adopting a short value chain, based completely in Italy, with the most sustainable practices.

Elbec truly believes that the key to making something sustainable is having a short supply chain and creating this type of reality where people make a difference and are not exploited or underpaid, stating that proximity is the key to sustainability nowadays.

Their project “Manifattura Diffusa” has a short supply chain, with the production based entirely in Italy, everything hand-made, everything produced with Italian wool.

They started with the aim of protecting and fighting for environmental preservation and sustainability because they truly believe in honesty and transparency, and the concept of sustainability as a way of life.

The wool comes from extensive organic farms, where the sheep, chosen for the short supply chain of hats production and other similar pieces of garments, live on pasture, feeding exclusively on the grass of the upland “Campo Imperatore” in Abruzzo. The sheep are then sheared, and they are no mulesing because in Italy there is no fly problem and they don’t use any kind of pesticides or antibiotics and these animals are healthy.

All their Merino wool is certified with no mulesing and they also have yarns with GOTS and ZQ fibers certifications.

The ELBEC MAnifattura Diffusa "widespread manufacturing project" has the objective of reaching total control of the supply chain by internalizing all the processes that include the breeding of the sheep, the raw materials, and the final delivery of the products.

Their goal is to have an entirely Italian zero-kilometre product within their control.

“Manifattura Diffusa” is an ambitious project that could lead to many satisfactions and new milestones in terms of sustainable practices.

At the moment the yarns they use are:

- 100% Organic Merino Wool spun, coming from Italian organic farms in which the merino sheep are not subjected to mutilation or processing

- 100% Italian Merinised Wool, raised, carded, and hand-dyed in Italy in an artisanal way.

- 70% Virgin Wool and 30% Organic Alpaca with GOTS and ICEA certification to ensure maximum respect for animals and end users.

Controlling the entire supply chain allows them to have true and complete traceability, which in this case is not certified by any authorized body, but that they know to be true and transparent because it is based on the close relationship between men and women who work in the sector, who know each other and who speak the same language.

The company's wool comes from the mountainous areas of Abruzzo, Molise, and northern Puglia: ideal natural pastures along the historic transhumance path host Merinised sheep. In winter, they will be housed in spacious stables where they will be taking in dry herbs and natural products; whereas in summer, they go out to mountain pastures.

The wool is hand-picked once a year in spring by an experienced Italian cooperative that guarantees responsible treatment without harming the animals.

Elbec works with small local breeders and supports sustainable, extensive farming to help small businesses survive. The focus is on low-impact, ethical farming. This generates more than 10 tons of wool annually for a high-quality and regionally sourced product. The goal is to help this ethical and sustainable model of production grow over time.

Furthermore, people involved in the production process can work from home and are paid fairly and this represents an additional income for them. They can work in front of the TV, during travels, or on vacation. Elbec contributes to the economic well-being of the families in the valley and they make a good and important impact from the social perspective. It is all part of its way of working and being sustainable.

Rifò and its circular sustainable value chain

What is important to highlight about Rifò is their local production and the proximity of their suppliers and production facilities (which is something similar to Elbec and their short value chain). This reduces transportation costs and the overall environmental impact., supporting traditions and boosting the local economy.

Starting from waste, they recycle old garments and fabrics, making new products and extending as much as possible their life cycle. In 2023 they recycled 14.1 tons of textile fibers and produced 72.169 clothes and accessories. In Figure 13 their circular value chain is represented.

Figure 13, Rifò's products life cycle

Source: (Rifò, 2023)

Like Marzotto, they have been assigned B-Corp certification, thanks to their transparent social and environmental commitment and performance. They have indeed an innovative production process starting from the recycling of textile waste, which is collected with a take-back service.

All textile materials are made of recycled fibers and are recyclable even at the end of their life cycle, ensuring the possibility of providing a second life. Furthermore, they use mostly natural fibers, instead of synthetic ones, as they are more polluting and less biodegradable, achieving production with 100% natural fibers in 2023.

They purchase yarns and fabrics from Italian suppliers, located within a range of 30km from the production facilities, including pre-consumer and post-consumer recycled fibers. Post-consumer fibers are collected thanks to the take-back service, with 230 collection points present in Italy and Central Europe.

Almost all their materials are certified according to international standards, such as GRS, RCS, and RWS (certifying mulesing-free processes).

Moreover, the exploitation of recycled materials allows a significant decrease in energy and water consumption, as well as less CO2 emissions and usage of chemicals.

A very important part of ensuring a circular economy is designing products that have the least possible impact on the environment, recycling materials, and extending the life cycle of each garment. In addition to using natural and sustainable fibers, Rifò is committed to designing clothes that can last as long as possible and be used on as many occasions as possible. Their price is transparent and includes the fair costs for the production of each item.

As for the dyeing and finishing processes, which are considered among the most polluting, most of their fabrics do not require further dyeing, since they come from discarded fabrics already separated by colour. When necessary, only natural and non-synthetic dyes are used, which contain a much smaller amount of harmful substances.

Another very interesting project is Zero Waste, which aims to minimize textile waste by creating products, especially accessories, that can then be put on sale.

- Pre-order model

A very common problem in the textile industry is overproduction. In fact, companies often produce a much higher quantity of clothes and accessories than the real demand of consumers. Rifò has solved this problem by creating a pre-order system that could respond exactly to the real needs of the market. It thus avoids having products at the end of the year that remain unsold in the warehouse. In fact, in 2023 only 10% of the clothes produced remained unsold.

- Green Week

Another beautiful initiative concerns Green Week, in opposition to Black Friday. The company strongly believes in attributing a real and honest cost every day of the year, not attributing discounts that do not reflect the history of the product.

5.3 TWIN TRANSITION AND THE MERGING OF NEW TECHNOLOGIES AND SUSTAINABILITY

In each case presented and analyzed, it was possible to see how technology and sustainability are two aspects that go hand in hand. Thanks to emerging technologies, it is possible to significantly improve the commitment towards the environment and sustainability within the textile value chain.

Both in long chains such as that of Marzotto and in shorter and more local chains, such as Elbec, and finally the circular ones, Rifò, it is proved how technology can support sustainable commitment and facilitate this process.

Depending on the type of value chain, technology supports sustainability in different ways, but in the end, a process of strong innovation always occurs, which in today's textile world is a fundamental need nowadays.

Marzotto and the twin transition

Especially for long-value chains, such as the one of the Marzotto group, it was possible to understand how technology can strongly support sustainability.

- Information technologies and improved communication across the value chain

This type of investment has significantly decreased the costs and emissions of transportation, improving communication and collaboration in a much faster and more sustainable way, avoiding misunderstandings, reducing waste in production, and promoting compliance with environmental regulations.

- Digital twin technology and sustainability

The usage of digital twin technology allows the creation of virtual prototypes of textile products that can be sent to clients to be seen and modified when necessary. This not only saves a lot of time but also reduces the need for transportation and usage of sample materials, which once had to be sent physically. Thus, the textile waste is significantly diminished during the design process.

- Energy-saving technologies within the industrial process

Typically, these are technologies that can be used across many industrial processes and various product categories, not just textiles.

1. They include systems for generating energy from renewable sources such as photovoltaic panels installed on the roofs of warehouses, methane cogeneration systems that simultaneously produce electricity and thermal energy to be used in the process, biomass-fired thermal power plants, hydroelectric or wind turbines, and geothermal heat pumps.

2. Plants or systems for recovering and reusing “thermal waste” (high-temperature emissions or wastewater).

3. High-efficiency electric motors and inverters to modulate the operating regime of machinery as conditions change.

- Technologies for reducing chemical impact/water consumption in finishing processes

1. New fabric washing machines can operate with lower water consumption than more traditional and dated machines.

2. In some types of textiles, it is also possible to reduce the liquor ratio in dyeing machines to consume less water.

3. Recovery and filtration systems are used to reuse part of the water waste by putting it back into the production cycle. In this way, it is possible to reduce the extraction of water from wells, springs, or rivers (from 30 to 70-80%)

4. New recipes and new formulations are studied together with suppliers of chemical products/auxiliaries/dyes to obtain the same results while reducing the "danger" of the products used.

- Technologies for the recovery/recycling of raw materials.

The Prato textile district is historically the most skilled in the recovery of wool waste and its reconversion into new raw material (carded yarns).

Further techniques for the mechanical and chemical recovery of other, even less noble, fibers are being studied and developed.

The underlying problem, however, is always the difficulty/impossibility of efficiently separating fibers of different natures (for example natural and synthetic) obtained from the recycling of mixed materials to obtain a pure recycled fiber to be used for the creation of new textile products. The aim is to gradually arrive at a circular economy in which not only processing waste but also end-of-life material is retransformed into new textile products. Downcycling is already quite widespread but it does not go exactly in this direction.

- Technologies for the production of low-impact alternative raw materials (artificial fibers).

Various companies/startups are presenting new textile fibers obtained from renewable sources such as algae, agricultural waste, and textile waste from cellulose fiber rather than from recovered animal fibers (recycled wool and fur fabrics). In some cases, these are chemical processes with a low environmental impact, in others particular enzymes and bacterial strains are used to digest the materials and then produce new protein chains.

The same artificial fibers from fossil oil sources (polyester and nylon) are now available on the market with comparable characteristics but derived from natural raw materials (biopolymers).

Here a theme of biodegradability comes into play: it is not certain that a biopolymer is biodegradable if dispersed in the environment while synthetic fibers from oil sources

with accelerated degradation in the environment are spreading (3-5 years instead of 200 years of degradation).

- Blockchain technology and sustainability for the textile value chain

As mentioned earlier, Marzotto Group has adopted blockchain technology to improve the traceability and transparency of their products. Alongside traceability, the concept of sustainability is crucial. This is an important aspect for them internally, increasingly required by the Fashion industry.

Rifò and the twin transition for its value chain

The brand Rifò exploits some of the emerging technologies to improve its sustainable commitment and make it as transparent as possible.

- Enhancement of the take-back service using blockchain technology.
- Usage of an online platform, BCome, to provide information related to the sustainability commitment of the garment.
- Use of a platform to show and be transparent about their suppliers and provide their detailed information and proximity to the production facilities.

TextileChain and the twin transition

The potential of blockchain technology for sustainability along the textile value chain has been something deeply discussed with the company Foodchain.

Foodchain has collaborated with a few companies in the sector to optimize their value chains. The project Textilechain has witnessed the collaboration with the “Linificio e Canipificio Nazionale”, part of the Marzotto Group, to trace the production of the linen fabrics, improving its transparency and process reliability. This project has allowed to monitor every phase of linen production, from its cultivation to the transformation into fabric, guaranteeing that every step was documented and verifiable.

High fashion brands, like Gucci and Prada, acknowledge the blockchain value to ensure their products’ authenticity and have already started using this technology to improve the traceability and sustainability of their supply and value chain.

Blockchain can support sustainability by tracing the usage of eco-friendly materials and making sure that production practices respect environmental standards. Many different Italian companies have already adopted these technologies to monitor and improve sustainability practices within their production. By tracking the energy consumption or using recycled materials to produce sustainable clothing and garments.

This not only improves the overall value chain sustainability but allows consumers to be more aware and conscious about their purchasing decisions.

Tracking the clothes or garments, from the origin of the fabrics to the final distribution, is indeed something that is becoming increasingly important, especially for those who are aware of sustainability and ethical issues, but even for those afraid of purchasing an inauthentic product.

Traceability becomes a crucial element for brand communication, allowing brands to prove their commitment to sustainability and quality. In some cases, the consumers showed to be willing to pay a higher price for the products that are authentic, traceable, and with an ethical production, which is a competitive advantage for brands adopting these technologies.

5.4 Findings

Figure 14, Findings

Digitalization, Sustainability, and the Twin Transition
An overview of their impact on the case studies

	The Marzotto Group	Elbec	Rifò
Type of value chain	Long and complex value chain	Short value chain	Short and Circular value chain
Digitalization and the company's value chains	• New information systems • CAD modelling and Digital Twin • RFID technology • Blockchain technology	• Blockchain technology	• DPP, Digital Password Passport • Open Supply Hub • Blockchain technology
Sustainability and the value chains	• ISO certifications • B Corp • Energy saving • Minimization of emissions • Waste management • End-to-end and service • Circular economy • Renewable resources	• Short chain and entire control • Italian value chain • Certification GOTS and ZQ • Organic no-mulesing • Helping local economy • Organic farms	• Recycling • B Corp • Take-back service • Green week • Make-to-order system • GRS,RCS,RWS certifications
Twin Transition	• Information technology and decreasing of transportantions • Digital twin and sustainability, less material waste • Energy saving technology • Water saving technologies • Innovative fibers • Recycling technology • Blockchain	• Blockchain technology	• DPP, Digital Password Passport • Open Supply Hub • Blockchain technology for the Take-back service

Source: own elaboration

Through this literature search first, and through the companies chosen as case studies, it was possible to learn how value chains, especially in the textile sector, are continuously subject to changes and challenges to which they must adapt.

The fashion world has been subjected to much criticism for years and to a growing awareness of the enormous impact it has on people and the environment.

In each case study, it was possible to grasp a strong desire to innovate and change a system that can no longer function and is becoming increasingly unsustainable.

Starting from the longest and most complex value chains, up to the short and circular ones, technology and sustainability create a pressing movement of innovation, which takes on different nuances in each different reality.

Starting from the theme of sustainability, each company has tried to adapt to respond to the need to become greener. Marzotto has thus adopted numerous practices that could minimize emissions and pollution due to production processes and the long value chain, also helping itself with the use of new technologies. It has thus started a new era where technology and sustainability can coexist hand in hand.

Elbec on the other hand is a much more recent brand that was born to reach the highest levels of sustainability and adopt this term as a real lifestyle. Here technology could represent a significant improvement in the efficiency of production systems and the adoption of technologies such as blockchain, to promote green practices and their local and handmade production, using top-quality materials. However, costs represent a significant obstacle, given that small businesses like theirs can find themselves in serious difficulty in being able to afford technologies of this type, as well as numerous certifications.

On the other hand, the case of Rifò has been highlighted, a brand that is becoming increasingly acclaimed and recognized.

Rifò was born precisely to combat these changes in the textile sector, proposing an innovative value chain. Circularity can be an effective and essential way to recover all the materials and clothes that are discarded every year, causing serious disposal problems and further polluting the environment. Here too, technology has created opportunities for sustainability, bringing together platforms like BCome and blockchain technology, to

promote and demonstrate their commitment to society and even more to the environment.

Each case has responded differently to the change in textile value chains, sometimes choosing to invest more in emerging technologies, as in the case of the long value chain. Sometimes instead trying to keep alive a local tradition that is part of a short chain with direct control of the different phases. Other times instead trying to create an innovative value chain by exploiting resources that in a normal value chain would have already been lost.

It was possible to note how in the case of Marzotto it is essential to invest also in new technologies to respond to the great needs of the market and customers, as well as in increasingly sustainable practices, given their importance and magnitude.

Managing a long and complex value chain requires continuous innovation and a careful evaluation of its emissions and impact.

As for Elbec, sustainability is the backbone of the brand. It stands out for its extraordinary attention starting from the sheep, from which the raw materials come, to the care of every detail in the hand-made products. It would be extraordinary if more brands contributed to the communities and gave value to jobs that are slowly disappearing.

Rifò then with its innovation, merges technology and sustainability creating a value chain that puts environmental protection at the forefront.

In all cases, a particular interest in technology that supports sustainability has been noted, as well as a general scepticism towards the awareness that consumers have for sustainability and the lack of standardization regarding certifications and regulations.

In any case, each brand has demonstrated how to face the uncertain scenario of today's market. The ability to adapt and the search for continuous innovative solutions are of primary necessity.

Conclusions

Global value chains are undergoing many changes and innovations that increasingly force companies, especially those with long and complex value chains, to adapt and continuously innovate.

The pandemic, emerging technologies, the unstable geopolitical situation, and a growing focus on sustainability issues have profoundly changed value chains and the ways of operating and managing relationships with different stakeholders.

Digitalization has created new opportunities that have helped create new business models, be more competitive in the market, and achieve increasingly higher and more important goals.

It has profoundly improved business operations and performances and has introduced numerous advantages and opportunities for different industries and different sectors. (UNCTAD, 2023a)

At the same time, however, there is a growing focus on sustainability and the environmental and social impact that these complex and long value chains create. The process of greening global value chains has become an increasingly widespread and increasingly important phenomenon, causing various governments to also commit to implementing rules aimed at this objective.

The achievement of the "Paris Agreement objectives", which sets long-term goals, the reduction of the overall harm caused to the environment as well as global GHG emissions, and a lower level of overexploitation of existing natural resources are just a few of the steps to be taken. (United Nations, 2023)

During the last year, there has been a growing interest in a new phenomenon called "the twin transition" that highlights the interconnectedness between green and sustainable policies and technological developments.

This change in value chains has been seen in particular in the textile industry.

As mentioned in "The State of Fashion 2024", the Fashion industry is responsible for between 3 percent and 8 percent of total greenhouse gas emissions. Extreme weather conditions are expected to harm $65 billion worth of apparel exports and eliminate

millions of jobs in 4 different economies that are the most central to the global fashion industry. (McKinsey & Company, 2023)

This is an industry that includes a vast number of companies with long and complex value chains, spread throughout the world. Digitalization and sustainability have particularly influenced this sector, creating numerous opportunities and advantages.

The textile manufacturing industry has proved to be slower regarding aligning novelties of digitalization concerning other industries and sectors. However, many technologies represent a real opportunity for the sector, and next-generation textile machines are now becoming more and more digitalized integrating capabilities of Artificial Intelligence and the Internet of Things. Thanks to these, it is possible to track the entire production process and make reports in real-time with other important functions.

Emerging technologies and sustainability have proved to be two aspects that go hand in hand and can complement each other creating numerous synergies and benefits, and twin transition is a phenomenon that is gaining more and more interest, especially in the textile industry.

Numerous technologies can support sustainability, significantly improving the overall impact of companies, like blockchain technology, which is becoming increasingly popular and is being adopted to ensure transparency and traceability within the value chain.

The research question was therefore to understand how emerging technologies and the growing attention to sustainability have affected different types of value chains in the textile sector and how technology and sustainability find a balance within each company and brand.

With in-depth research and in-depth analysis of case studies with interviews, it was possible to understand how the responses to these changes can vary based on the value chain.

In long and complex value chains, technology becomes essential to improve communication and collaboration and, at the same time, increasingly sustainable practices become a primary necessity.

The case of Marzotto showed how many technologies such as new information technologies, Digital Twin, energy and water saving technologies, and technologies for recovery and recycling are being used to improve the sustainability commitment.

Elbec, on the other side, thanks to its short value chain, can deliver sustainable products with a traceable and verifiable value chain, from the suppliers to the final delivery part.

For shorter value chains, technology can be a great opportunity but it also represents an obstacle given the difficulties and costs of adoption. Sustainability instead becomes a way of life and not a simple marketing policy as in fast fashion brands.

Rifò is another example of how technologies such as blockchain and online platforms, are exploited to improve and verify the greening process of the value chains. With its circular value chain, which re-cycles and provides a new life to old garments and clothes, can exploit new technology to smooth the entire production and transformation process, and a the same time prove the proximity and origin of its suppliers, providing numerous details and information.

Recycling and upcycling are two phenomena that are growing more and more and are becoming a valuable tool for collecting and disposing of waste that would otherwise further pollute the environment.

Blockchain technology has emerged as a key technology of the twin transition process, within the analysis of the cases, highly adopted to trace every step of the value chain and make the production process more efficient and more sustainable. At the same time promoting high-quality standards and proving responsible behaviour. Textilechain, the technology provider analyzed, gave a significant contribution to understanding the numerous advantages of this technology related to the value chain and the sustainability aspect.

A key contribution of the thesis is its focus on the "twin transition," the synchronized force towards digitalization and sustainability, which is becoming increasingly important across industries. By exploring this phenomenon within the textile sector, the work highlights how these two trends are intertwined, driving both environmental responsibility and technological advancement.

Through in-depth case studies of three companies—Marzotto, Elbec, and Rifò—the thesis shows how different types of value chains are responding to these challenges.

The thesis sheds a light on the importance of innovative value chains in managing environmental challenges. Because of the stricter environmental regulations, the textile industry must continue to adapt, and the work contributes to this conversation by offering a detailed analysis of how companies are already responding to these demands.

Innovative value chains are the future of the textile industry and will have to respond more and more to the emergence of new technologies and increasingly stricter rules regarding environmental protection.

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Appendix A

Case Study 1

Interview "Marzotto Wool Manufacturing"

The interview was conducted with three managers from "Marzotto wool manufacturing", which produces and distributes wool fabrics for apparel.

There is also the part of Marzotto Lab, which handles other types of products, including home furnishing, knitting yarn, and cotton.

To make a wool fabric, which accounts for 95 percent of their turnover, the process starts with thread, therefore weft thread and warp thread. The thread is made from the raw material which is the wool, that comes from the sheep and is known as greasy wool.

To be able to get to the wire instead, you need to go through an intermediate phase, which includes cleaning the wool, to remove soil, vegetables, and other impurities; once the cleaning is done, the wool fibers are carded to be aligned and made easier to handle for spinning. When the carding is done, which is the phase in textile production that includes the separation and organization of fibers, the wool is ready to be spun into yarn.

This entire process starts with the wool purchase from sheep and then there is the combing, spinning, and weaving of the wool. Their work and involvement in the Marzotto wool manufacturing stops at this point.

During the weaving stage, the next steps include raw weaving, finishing, and dyeing. Dyeing can be done at different stages: on the initial, yarn, or finished fabric.

At Marzotto, they primarily focus on wool. However, they also produce cotton and linen in other fabrics located in different sites. Despite the differences in the production methods, the process and the logic behind it remain almost the same.

After the first part was dedicated to explaining and introducing the main activities and processes done by Marzotto wool manufacturing, the conversation started to go deeper into the concept and the use of blockchain technology.

Answer

Here, it is done with particular machines, using certain parameters and specific batches of chemicals, and performed by certain individuals. Therefore, to trace everything, one would need to know who sheared the sheep, the name of the sheep, which farm the batch of wool came from, which machines it was washed on, when, in which facility, with what parameters, and so on.

On which spinning machine the thread was made, using which batch of wool, and which lot.

We have a series of codes that transition from one phase to another, organized in blocks. When we receive a batch of wool that is already combed, washed, and ready for dyeing, we assign it a number. We know where this batch came from, the farm, and which facility it was processed and combed in. Then the dyeing process is done and the batch assumes another code. This batch of wool was used to produce various dyeing batches, which then generated different spinning batches, finally generating several different fabrics.

These fabrics are then utilized to manufacture pieces that are transferred to the customer, each recognized by a unique serial number. So, at each phase, new codes are added.

The purpose of this tracing system is clear when a customer reports an issue. For instance, if a customer says, "I made 50 jackets with your fabric and the color is rubbing off onto my hands." The customer is then asked to give the order details and they would go back to the specific fabric rolls used in the problematic jackets. Each roll possesses a serial number, allowing them to see the entire process it went through—whether it was piece-dyed or yarn-dyed.

We can then identify which spinning batches were used in those fabrics, the wool batch used, and the processing details. We can trace every stage of production. Sometimes it's straightforward, but other times it's quite complex. For instance, you might start with the fabric serial number, which gives you the weaving batch, then trace the spinning batches, and finally the wool lot.

The process involves accessing different systems and cross-referencing codes. Although we can eventually trace all the information, it can be very detailed and challenging.

So, this tracking system is essential for the internal processes within the company, not just for the final consumer. The final consumer does not receive these detailed pieces of information—they are far too detailed. Even the garment manufacturers sometimes struggle with this. Each garment, especially outerwear, has its internal code indicating the batch of fabric used.

What is a cutting batch? It means that I took 8 pieces of fabric, cut them, and from there, made the garments. Even they can trace back, though not always easily, to which fabric rolls were used for making a specific garment. The process is complex because each industry player typically keeps accessible only the data they need, not all the supplier information.

Ultimately, even we don't see the wool batch information easily. We have to search for it to understand which wool batch was involved. We keep close track of the information relevant to our process. That's the point of it.

When you mention blockchain, what does it mean? Imagine blockchain doesn't exist. It would mean that we need to have a series of information that we can make available. However, someone might ask, "But who guarantees you're not making this up?" That's where the system comes in, to ensure this information is accurate and certified. Blockchain provides this kind of security in some way.

Because every time you use blockchain to record data it's like writing in stone.

For example, Mario dyed the fabric this color on day X. No one can later claim it was Paolo instead of Mario because it was recorded at that moment. That information can't be changed. So, having a blockchain that supports these data with a validation system ensures that the information is accurate and trustworthy. You can be confident that you're not being fooled. However, blockchain is simply a way of recording information.

It's the marble and the chisel, but if you don't know what to write, blockchain is useless. Absolutely.

In our field, rather than talking about blockchain, we should focus on traceability. It's in our interest to track the origin and components of every material and fabric we sell. This is crucial not only for our own records but also because certification requirements are increasingly stringent. We are the first to benefit from tracking all this information.

For the end consumer, when you buy a garment, knowing the exact farm where a component came from might not matter much. What does matter is that the product was made following standards that respect all general rights and principles.

Alongside traceability, the concept of sustainability is also crucial. This is an important aspect for us internally, as it is increasingly demanded by our market, which consists of companies that produce and sell garments. Within our group, we are very complex and extensive. We have a couple of projects labeled as blockchain, but they are more about traceability, material origins, and similar concepts.

The issue is that there isn't just one blockchain.

Each entity uses different methods, like various types of marble, calligraphy, and chisels. If I write in hieroglyphs on alabaster and you write in cuneiform on clay, we can't understand each other. The problem is that there isn't a common system for all weavers and garment makers worldwide to ensure consistent communication.

Each brand or company is trying to find its way of doing this. But we don't supply only to Hugo Boss or Max Mara; we have hundreds of clients. It's challenging to manage hundreds of different ways of recording information. This lack of standardization creates significant difficulties in sharing information.

Every client proposes their solution, which often involves a portal where we must upload the requested details. Sometimes, these details are almost excessive. This is a problem. As Roberto mentioned, there is no standard.

There isn't a universal system for blockchain or for tracing and certifying information. Various initiatives and standards exist, but they aren't global or recognized by everyone. Different regions and sectors have their standards for various fibers like cotton, wool, and others. It's a very complex and intricate world, lacking clear and defined legislation, at least at the European level, which adds to the confusion.

Every client, and thus every country, launches their initiatives. Some are more structured, while others are created entirely ad hoc. For instance, France has established a system that applies within its borders. They have created a portal called "Fairly Made", and in principle, all French clients refer to that portal.

At least not everyone is proposing their own system. Other countries are not following the same path. The issue is the lack of clear regulation, at least at the European level. We live in a global world, and this aspect should be addressed by early 2027.

Here we're discussing the actual information itself, not just how it's recorded. It's not about calligraphy; it's about the content—essentially poetry. The technology isn't the issue.

It all begins with clear, defined rules because otherwise, everyone builds their own solution. Let me give you another example: someone might claim, "My clothing is more sustainable than yours." This often leads to greenwashing.

What does sustainable mean? For instance, my sweater might have used much less water to produce compared to yours. Consider this: take a wool sweater and a polyester sweater. Polyester uses very little water in its production process. Wool, on the other hand, requires a lot of water—it needs multiple washes to remove grease and dirt from the fiber of the sheep. Then there's spinning, dyeing, and so on; it's quite different.

But here's the thing: at the end of the day, you wear the polyester sweater for a couple of days, then either wash it or toss it because it pills and looks dreadful. The wool sweater, however, remains fresh and good even after wearing it several times.

So, theoretically, the initial production process of the wool sweater might consume more water, but over its lifespan, it will use much less. When eventually discarded, the wool sweater will biodegrade in the environment.

A polyester sweater can remain in the environment for 300-400 years. Moreover, each time it's washed, it sheds microfibers that end up in the oceans, contributing to marine pollution. So, what does sustainability mean in this context? Depending on how sustainability is assessed—based on a sustainability label or score—a product's characteristics can be emphasized to favour its sustainability claims.

Therefore, it's always challenging to be entirely objective because perspectives on sustainability can vary. Factors to consider include water consumption during production, end-of-life considerations, product usage impacts, energy consumption, the presence of chemicals, and whether the source is renewable or fossil-based. There are numerous parameters to evaluate.

The weight that each parameter has depends on the different interests that each group has while developing these methodologies. Luckily, there are ISO standards made for sustainability that enable transparency of the products and promote practices to limit their impacts. Even though standards provide clear methodologies and practices that have to be applied, there is still a lot of confusion and not a clear direction to be followed and pursued by everyone.

This applies even more to the concept of traceability. For sustainability to be recorded, tracked, and verified, it is not enough to have the correct and proper information, the entire process must be done using methodologies that rely upon the ISO standards. Only at this point, does the digital passport of the product have a value with certified data, registered correctly, as standardized and recognized methodologies have been used. Thus traceability and sustainability go together and this connection is crucial and fundamental, as there cannot be sustainability without traceability.

About the value chain

- How are the suppliers distributed around the world? Are they mainly around Italy or more widespread?

When talking about wool, the major producer, especially for clothing, it's Australia. Compared to 5 years ago, when 90% of the wool purchases came from Australia, nowadays it is around 70%. The other areas of production are South Africa and South America. These are the main regions where the suppliers are located and New Zealand, as an important supplier, covers the needs of other divisions of the Marzotto group, such as home furnishings, blankets, and similar products.

- Considering the geopolitical situation in recent years, including the COVID-19 pandemic and the conflicts, was there a change in the dynamics inside the value chain, and what were the actions taken to adapt and survive the new reality?

There have been obvious changes in the dynamics and relationships. Still, becoming less dependent on China and creating production facilities in Europe and the United States has been an idea mostly theoretical and far from reality.

Additionally, the Marzotto group has partner factories in Egypt and Biella that deal with a part of the production and it is really important to know that they are the largest producer of wool in the world.

However, wool represents only a small percentage of the global textile fiber market. It used to account for a higher percentage, but now it is only 0.9%. The main fiber in the global textile industry is polyester.

- What about the geographical distribution of the clients?
- Did new technologies have an impact?

Their clients are spread worldwide and present in a lot of different countries, including very prestigious brands. Every known brand in the clothing industry has been probably their client or it is now. Even the knitwear sector, through the Lab division, they are present in the final clothes and products of many brands.

In recent years, new technology developments have certainly improved relationships and communication with distributors and suppliers around the globe, but not all the issues have been solved, as the recent events have deeply tested global value chain resilience.

COVID-19 has created many delays in deliveries and has created many supply chain disruptions for months.

Therefore, it cannot be said that the management of supplier relationships has improved in terms of delivery time efficiency.

- Efficiency of customer relationships

Information systems and data exchange: From the point of view of customer relations, there has been a significant improvement thanks to the integration of information systems. Although we cannot say there is a complete automatic connection between systems, there has been considerable development in this direction. Data exchange has become more fluid and efficient, making management and communication with customers easier.

In conclusion, while technology has helped improve customer relationship management through better information systems and data exchange, the pandemic has caused serious

delays and logistical problems that have negatively impacted the efficiency of supplier relationships. Our commitment remains to continue to improve these processes, adapt to global challenges, and make the most of the available technological innovations.

New technologies have definitively impacted textile value chains, enabling big clients to see all the fabric and the pieces and whether they have already been placed in the warehouse or shipped. Clients can see in every single moment the deliveries and make real-time requests. Years ago this was not possible and everything was done by phone calls and it took a lot of time. Now this exchange of data and information and simply asking for updates it's much smoother and faster.

Even the design process had some significant improvements, as the clients can have a proper feeling of the textiles and pieces thanks to the information system that once would have been almost impossible and would have required producing and sending physical samples. The clients would receive the samples, review them, and then discuss them. The majority of this process is conducted online now.

Marzotto Group launched also a project 5 years ago in collaboration with Hugo Boss. Essentially, when they create a new garment or fabric for a season, twice a year trends and fabrics are presented. However, when there are clients with specific and exclusive requests, there has been a real improvement in the entire process that involves multiple physical trials, as before various samples had to be produced and sent before the choice was made. Thanks to the development of new textile CAD modeling systems and garment CAD systems, manufacturers are now able to model the garment in 3D. It becomes possible to model the garment in 3D and simulate the stitching of various panels. They can see the final tailored model and overlay the image of the fabric on it.

This image is so much more than a photo; it includes the roughness, transparency, tridimensional shape of the weave, color, thickness, drape, and bend angle. So when it is overlayed on the virtual mannequin, the virtual body, the virtual garments fall perfectly with the weight and curves of the arm and conform to the shape of the body as it is real. It is almost impossible to distinguish the photo of the virtual and the actual garment and the first one seems more realistic sometimes.

In this way, they said, "Don't send me the fabric; design it for me, send me the data, the surface details, how it's made, and I'll apply it to my virtual prototype. I'll photograph it,

see how it looks, make changes, and tell you to make the check pattern a bit wider." I can modify it in the system, send it back, and within three days, it's done. You've defined exactly what the client wants, and then you go into production. Previously, this process would take a month, with back-and-forth sending of physical samples, making garments, and sending them back and forth. It's incredible how much this new technology has streamlined the process. It's a shame that only a few use it; many still rely on physical paper prints and fabric samples, making it hard to move away from traditional methods.

There have been these steps or these new opportunities, perhaps pushed by some customers, first and foremost Hugo Boss, who have somehow exploited the very concept of digital twins. They are using it, and they have exploited it, but at the same time it is possible to notice that there is no request from many customers or other customers, the same Hugo Boss who had pushed it is now in a phase where it has become more hesitant about it.

The world of textiles is very particular and delicate. During the pandemic, this technology was pushed as a tool and it represented such an excellent opportunity, but now that relationships have started again, our world expects relations and content to regain their importance. People expect to see the fabric, to touch it, and there are still these mechanisms that limit the potential of technology.

However, that is a path that will be indispensable and that, maturing over time, will certainly reach a complementary level and impact the relationships between companies and customers, but it will never become a substitute and replace the physical experience.

This is because when you enter a store, the first thing you do, you see the dress, you touch it, you feel it with your hands, this is something that “unfortunately or fortunately” is irreplaceable and therefore many designers, stylists want to feel the fabric with their hands and they cannot choose it without touching it. They work on the touch and on what type of sensations that certain fabric gives to people and it is almost impossible to eliminate that experience, which cannot be replaced by technology and innovations.

So there is technology that helps you, but an emotional part remains linked to the five classic senses. Specifically, it is precisely our type of product that has these, if you like, characteristics or limits, because for other simpler products, such as t-shirts with prints or things like that, digital represents itself a perfect way to completely replace the physical

garment for the entire design and simulation phase and so on. “It is precisely the characteristic of our fabric that lives, yes, on the design, but has the value very much in its, how to say, in its hand, in its particularity, in its components precisely.”

It is possible to differentiate a cashmere scarf from a polyester one because when you feel them and touch them with your hands you can tell that there is a big difference.

If we take a sweater as an example, when you see it on the site you are probably going to buy the polyester one because it costs less. However, when it finally reaches home, you become a little less happy, understanding the true quality of the material used.

- What other elements of the Fourth Industrial Revolution have been integrated within your firm (e.g., IoT, artificial intelligence, big data)? Do you use the Digital Twin technology?

We had some types of machines, typically weaving looms, which are the machines that intertwine the warp and weft to build the fabric, something that existed before it was even called 4.0. These Looms could receive instructions directly from the CAD, where we designed the models. So instead of sitting and manually inserting the different parameters on the machine, which was a long process with a lot of different data requested, we could transfer all of the necessary settings, passed from the CAD system, which was what we called a CAM file, directly to the loom. In this way, the operator simply typed in the name of the item to be made and the loom received the weave and set itself up automatically.

This is fortunately something that was present even 20 years ago. The Industry 4.0 has even pushed further in this direction and if before it was present especially on the loom machines, nowadays the transfer of settings to many different machines is much faster, simpler and automatic. These machines can perform different tasks, sometimes simpler, such as setting only two or three parameters, such as speed and temperature, depending on the needs of the machine.

In addition, machines now provide us with detailed information about what they are doing. They are able to report what particular piece of fabric they have been processing at 10.40 AM compared to before when it was necessary to put a stamp on a piece of paper

to show it was done. It can even provide more information and say: "I was doing it at 10.40 AM, I was going at 40 meters per minute, at how many degrees, using a bath that impregnated the fabric with what substance and from what particular supply batch. Namely, it provides a lot of details and information that are then collected and analysed. This can serve as a retrospective analysis to report if there was an issue and see if something particular has happened, or provide statistical analysis and keep track of the quality and the production process.

Today, we are witnessing a phase in which this progress of the process is registered automatically, and there is no need to use stamps or any type of documentation. Progress depends still on the type of machine; in some technology has already proved its power and has brought many novelties and innovations, while in others there is still so much work to be done.

Then there is the integration of the RFID project that was developed in the area where these machines operate. With specific tools, a whole hardware and software solution has been implemented for the automatic detection of fabric progress and advancement, which we identify as pieces, whether they are smaller pieces or larger rolls.

Therefore, the manual intervention of the person is no longer necessary, but everything is detected with specific chips. Each chip has the name and the serial number of the single piece that the system already knows and automatically creates a repository. In this depository, which could be considered similar to a big data system, we track each number and all the advancements steps within the finishing department. This department is quite complex, as it involves a processing of more than 20 steps and involves 20 different machines.

Each piece of fabric, whether it is 70 meters or 210 meters long, has a heat-sealed label under which there is a mini RFID chip. This chip records the serial number of the fabric, which then enters the machine where antennas can read it and in real-time process and send the data to the system.

- How much it is important to invest, once new technologies have been adopted, in employee training to better manage new operational changes?

Investing in the training of our employees is extremely important to better manage new technologies and their adoption within the industrial processes. We are manufacturers and it is obvious that hands are the core focus of our work. Even if we purchase the best and the latest machinery available on the market, in the textile sector, the machine is as important as the employer and the person who operates it.

For example, we have a machine that operates 40 meters per minute, drying the fabric. If it enters crooked or with a crease, and the operator doesn't see that immediately, even a few seconds of distraction can cause a scrap of 20 meters and a loss of 400 euros. It is thus fundamental that the worker is trained properly to manage the machine and control the entire process avoiding any kind of problem.

Technical training is essential even for the more manual tasks, like fixing broken threads on the loom, and not only to know how to use the machinery. Every job inside our reality, even the more manual ones, requires a lot of time commitment and learning to be fully understood and incorporated and reach a basic level of working on the machine without committing errors.

As machines become more automated and programmable, employers might have fewer manual things to do and be able to interact with them and use the touchscreen, making sure that all the data settings have been correctly inserted and possible errors in the systems are being discovered. It's like when you work on an Excel paper: if you make a mistake with the formula, all the calculations turn out wrong.

Today, everyone uses a smartphone and a computer so there is not much "fear" of technology like there was 20 years ago. However, it is still important to maintain things, not that simple, and make workers commit and reach the levels when they can tell, by just touching the textiles, whether something is wrong or everything has been done properly.

We have a big factory in the Czech Republic, and people there come from different countries, such as Mongolia, Ukraine, and many other places with their respective languages. Sometimes you would even need two interpreters for people to understand each other; that is a nightmare. Hardly any of these workers have professional skills, and you need to train them in everything. In this case, you have to make things so simple, or you are going to have a high turnover of people that you constantly need to train again.

You have to simplify as much as possible because, in some cases, there is not the time to develop high-levels of expertise.

Nevertheless the extensive expertise acquired over two decades in an artisanal industry is priceless. Our seasoned employees have the ability to detect flaws by the sound or sensation a skill essential for upholding quality and achieving excellence. They are aware that even if a process functions effectively there could be room for improvement prompting them to address any issues. Without this level of understanding the risk of causing more harm, than good is heightened. Even though technology and automation provide support to us all the human element remains crucial in our work—it's indispensable.

- The last question is about your role in the territory. Are there other realities like yours in the Veneto region that are similar and maybe following your operations and using you as a role model? Even talking about the investment in new technologies?

In the Veneto region, there are some textile companies similar to ours, even though they are smaller and some of them cover different market segments. We are a reference for some things but the main textile district is in Biella. Here there are many different factories, companies and historic producers, some older like us and others younger. They have created a district and everyone knows each other. They have created a social fabric that includes weavers, finishers, and fabric operatives. Many people have also families that are working in the same sector: the mother might be doing seam finishing at home, the father is the weaver and the uncle works in finishing so that everyone has a role.

There, there is a deeply rooted culture and maybe this is something we lack cause we are not in a district of different companies.

While we do showcase our proficiency in the field of work with confidence; simultaneously being an entity in our own right as a company named Marzotto Biella establishes and upholds a productive connection with our fellow counterparts in Biella town. When acquiring machinery for operations purposes; it is customary for us to engage in discussions regarding the choices made by others in similar positions and installations carried out by them which prompts us to physically inspect these equipment. During these exchanges of ideas and experiences; statements, like "I've given it a try but my satisfaction

is moderate" or " not. Its truly remarkable" are shared among us. Communication and mutual respect are essential in any interaction, between individuals.

In addition to that point mentioned earlier about trade shows and how we explore market segments there – our range of commercial displays and products is extensive and constantly pushing the boundaries of innovation. It's amazing to see the number of visitors who are drawn to our displays for inspiration purposes. A key focus, for us is ensuring that we positively contribute to the community.

CASE STUDY 2

Interview Textilechain

Textilechain and the main benefits of the blockchain technology

- Can you explain briefly how did you come up with the idea of your project and what was the main intention in creating a technology that could help businesses to keep track of the value chain in the food industry?

Foodchain Spa was born with the intention of bringing the concepts of transparency and traceability inside the agri-food industry using the blockchain technology. The necessity of ensuring food safety, product authenticity and meet the growing consumers' requests of knowing the provenance and the quality of the food they are consuming were the objectives behind this initiative. The blockchain technology allows registering immutably every step of the value chain, offering a safe and reliable way for monitoring the entire products' life cycles.

The need to fight against phenomena like Italian Sounding and food counterfeiting represented another reason for its realization. The Italian Sounding phenomenon refers to the adoption of names, colours, images and brands that are associated to Italy to promote products that are far from Italian products. Not only this phenomenon deceives consumers, but also it harms the authentic Italian producers. The food counterfeiting, which comprises falsified or adulterated products, presents a serious risk for public health and threaten consumers' trust.

The blockchain offers an efficient solution to these problems, ensuring that every product can be tracked from the producer to the final consumer, guaranteeing authenticity and integrity.

- What led you to transfer this traceability model of "Foodchain" within the textile and fashion industry? What were the main opportunities that you have foreseen? Have some technology providers already been present in the market?

The transition from the agri-food to the textile and fashion sector was driven mainly by the growing demand for transparency and sustainability. Foodchain identified the opportunity to apply its knowledge, experience and technology to deal with similar issues,

like textile authenticity and ethical working conditions. There were already present some solutions in the market, but Foodchain saw the chance of significantly improving efficiency and security of existing solutions thanks to its blockchain technology, launching a project called “Textilechain”.

The fashion and textile industry have similar complexities to the ones of the agri-food industry, with global value chains that comprise many different actors and processes. Furthermore, the counterfeit problem is particularly relevant in this industry. Blockchain, with its ability of creating immutable and verifiable ledgers, offers a powerful and effective solution to guarantee products’ authenticity and fight against counterfeit, thus protecting brands and consumers.

- As blockchain technology providers, which type of advantages do you think the textile value chain can gain? (transparency increase, traceability, greater security)

Blockchain offers numerous advantages for the textile value chains. One of the most important is the higher transparency, because every phase of production, from the raw materials to the final product, is registered and can be verified independently.

The traceability allows firms to monitor and keep track of the entire journey of each product’s component, guaranteeing that every part of the process is conducted respecting the quality standards and sustainability standards, which have been declared. This technology can provide a greater security, reducing risk of counterfeit and fraud, because every transaction is registered in an immutable and verifiable manner. This not only does protect the brands, but increases trust among consumers for the products they purchase.

- What are the main benefits that the different actors inside the value chain can obtain? (suppliers of raw materials, producers and distributors)?

All the different participants of the value chain can perceive the main benefits of the blockchain technology.

The suppliers can certify the provenance and the quality of their products, making information available for all the following actors of the chain.

The producers can better manage the supply chain, reducing risks related the supply and improving the operating efficiency. The transparency provided by the blockchain can help identify and solve rapidly possible issues related to the supply chain.

Finally, the distributors can offer major transparency to their clients, allowing them to trace the product and verify its authenticity and ethics. This growing transparency can be translated into a higher costumer's loyalty and competitive advantage in the market.

- Could you provide some concrete examples of how the blockchain technology have already improved the value chain of one of your clients? Are there premium brands using it?

Foodchain has collaborated with few companies of the sector to optimize their value chain. The project Textilechain has witnessed the collaboration with the "Linificio e Canipificio Nazionale" to trace the production of the linen fabrics, improving its transparency and process reliability. This project has allowed to monitor every phase of the linen production, from its cultivation to the transformation into fabric, guaranteeing that every step was documented and verifiable.

High fashion brands, like Gucci and Prada, acknowledge the blockchain value to ensure their products' authenticity and have already started using this technology to improve the traceability and the sustainability of their supply and value chain.

Another important example is about the NFT (Non-Fungible Token) adoption for the limited edition products. The NFTs, which are unique tokens registered in the blockchain, can be used to certify authenticity and the characteristics of their exclusive products. Some fashion brands have started releasing their NFTs related to their luxury, limited edition, products. These digital tokens ensure that every piece of garment is unique and unfalsifiable, offering a proof of originality and a complete traceability from the production to the final sale.

- Can the blockchain contribute to the sustainability commitments in the textile sector? If yes, how? Could you provide me with some realities in the Veneto region?

Blockchain can support sustainability by tracing the usage of eco-friendly materials and making sure that production practices respect the environmental standards. We don't

have clients in Veneto so that we can directly tell you about their history but many different Italian companies have already adopted these technologies to monitor and improve sustainability practices within their production. By tracking the energy consumption or using recycled materials to produce sustainable clothing and garment.

This not only improves the overall value chain sustainability, but allows consumers to be more aware and conscious about their purchasing decisions.

- How much do you think it is important for consumers to track a piece of clothing from the origin of the fibers to the final distribution? Do you think it is something more and more important for brands?

Tracking the clothes or garments, from the origin of the fabrics to the final distribution, is something that is becoming increasingly important, especially for those who are aware of sustainability and ethical issues, but even for those afraid of purchasing an inauthentic product.

Traceability becomes a crucial element for brand communication, allowing brands to prove their commitment to sustainability and quality. In some cases, the consumers showed to be willing to pay a higher price for products that are authentic, traceable, and with ethical production, which is a competitive advantage for brands adopting these technologies.

Simultaneously, the capacity to prevent counterfeiting is a further element increasing customers' loyalty, cause they can be sure about the originality of the products they're buying.

- Which role do you think you have for the companies' strategies, as blockchain providers?

Foodchain considers itself a strategic partner essential for the firms, offering not only an advanced type of technology, but also a guide and a supporter for the blockchain implementation.

Our experience and skills make us a reference point for firms that are willing to improve their traceability and transparency. This collaborative approach allow to create an added value that is really important in supporting businesses to reach their strategic goals.

The relationship between Foodchain and the businesses represents a win-win model. On one side, our firm provide technical skills and the necessary technology to improve traceability, transparency and sustainability for the supply chains. On the other side, firms gain a competitive advantage thanks to the greater consumers' loyalty, an efficient protection against counterfeit and an overall improvement of the operative effectiveness. This synergy creates mutual benefits and makes us maintain long-term relationships with our clients.

- How did this project evolve during the last years? Was there an increase in interested firms?

In the last years, the project has been evolving and we have seen a strong increase in the interested firms, especially if they sell to foreign markets to grant value to their Made in Italy productions.

The interest increased simultaneously due to the growth in the blockchain benefits and the appearance of more accessible technologies. This trend will definitely keep on growing, with a major adoption of blockchain even in more sectors. The ability to prevent counterfeiting has had an essential role in the firms' interest increase because the technology offers very efficient protection against fraud and imitations.

- Are there other technologies able to track the textile value chain?

Other than blockchain, other technologies such as IoT (Internet of Things), RFID (Radio Frequency Identification), and advanced systems for supply chain management are used to trace the textile value chain. All technologies that have been evolving simultaneously to the blockchain over the years can be integrated into solutions like our traceability platform.

Blockchain offers a higher level of security and immutability, which other technologies cannot. However, all of them can be integrated with the blockchain to further improve traceability and transparency.

IoT allows the collection of real-time data through sensors in the entire supply chain, monitoring parameters like temperature, humidity, and location. These data can be registered in the blockchain, creating an immutable and verifiable ledger of information.

RFID facilitates the identification and monitoring of the products, and the collected data can be integrated into the blockchain to guarantee security and immutability.

The management system of the supply chain coordinates and optimizes the logistic and production processes, integrating data from the sensors IoT, and RFID tags to provide a full observation of the supply chain. The adoption of the blockchain within these systems guarantees that all the information is secure and immutable, improving transparency and processes' reliability.

- What are the main challenges you have faced in integrating blockchain technology inside the textile sector?

The major challenges faced in integrating blockchain technology in this sector comprise the resistance to change of the traditional companies, the initial costs of implementation, and the necessity of educating and training the different actors of the value chain about the use of this technology. Many Italian firms are used to operating using traditional systems and might be unwilling to invest in new technologies without a clear vision of all the benefits.

With time and growing recognition of the benefits, these challenges are becoming more manageable, and the adoption of blockchain in the textile industry will continue to grow.

CASE STUDY 3

Interview Elbec

They make products with a particular focus on the quality of the materials and commit to environmentally friendly practices in all the production phases.

- Can you explain better what you mean by short supply chain and which advantages it has for the textile industry?

Even though our situation is in constant evolution nowadays, we started 10 years ago and we have two different productions. One more industrial where we use Merino wool, coming from New Zealand, and not Australia, to produce our socks.

Then we have a second project, called "Manifattura Diffusa", which represents a short supply chain, with the production based entirely in Italy, everything hand-made, everything produced with Italian wool. Thus, they are two separate projects, very different from each other.

We've started with the aim of protecting and fighting for environmental preservation and sustainability because we believed in these issues and preventing cruel practices such as "mulesing".

Nowadays we can surely say that the short value chain project "Manifattura Diffusa" is something we are proud of and can confirm it is entirely sustainable.

Regarding the affirmation that we in general are increasingly committed to sustainability issues, I do not fully agree with this sentence. I have the impression that we are paying less and less attention to sustainability, as it has become strictly related to marketing. Rapidly everything in the market has evolved to appear much greener, but in reality, it remained quite the same as before. This is something of concern for me.

I remember when we went year before the pandemic to the Berlin Fair of Sport ISPO with our brand Elbec, as we focus on technical apparel products. Suddenly all the sheep seemed to be happy, the wool was mulesing free, all children were no longer working or exploited in Bangladesh to make sponsored t-shirts, with schools provided by Patagonia. In just one

year everything seemed to be green and this is what actually scares me. Much of these manifests are related solely to marketing and have no evidence.

For example, take the brand Patagonia, which promotes its recycled polyester. If you take into consideration how recycled polyester is actually made, you can find out it is the least sustainable thing on earth. When you buy their products that are made in Thailand and China, with all of the certifications they have, you are convinced you are saving the planet. However, you are buying an excellent piece of garment, cause they are of quality, but not sustainable at all.

You believe you are making an important contribution by supporting the brand Patagonia, which is very often associated with green fabric and sustainability. This represents their main strength and this is why I am sceptical about all of this.

Regarding blockchain technology, we have been contacted by some providers, as regulations are constraining all brands from integrating the digital passport of garments by 2030. This digital passport should explain the history of the product and make transparent and verifiable the entire value chain.

The adoption of this technology could range from 5000 to 6000 euros per product and while the costs could decrease for the subsequent products, they are still very high for a reality like ours. In this way what happens? On one side, larger companies are ahead as they can afford such expensive operations, which is something usual with European policy. These costly operations represent a huge disadvantage for small businesses.

Furthermore, what is worrying about blockchain is that you are allowed to say what you want and it certifies what you want to certify. A third party does not complete a control or verification of the things you are declaring. In this way, the digital passport can state that my wool comes from Germany and is non-mulesing, just because I decided to say that.

So it is often related to marketing and it seems like those who can afford it can become green, on the other side of the coin there are small businesses truly sustainable and committed but do not have enough money. Everything is a huge paradox in the world right now and can be applied to many other things.

Our project of Manifattura Diffusa, which we love, could serve you as an important example. We purchase wool directly from the shepherds in Abruzzo, who have been

chosen for our short supply chain of hats production and other similar pieces of garments. All of these shepherds do not have any type of certification.

On the other side when I buy GOZ-certified wool from Australia, it is incredibly expensive and not sustainable at all, because it produces a huge quantity of CO2 during the logistic phase, as the journey they have to undertake is long.

It starts in Australia or New Zealand, then goes to China, because they control a big part of the Merino wool. During this process they do what they want, delivering the certifications they prefer. The wool then goes to Germany, where there is the woven phase, then passes to Italy for dyeing, and then back to Germany. We buy it and then transfer it to Belluno, where there is the production of our socks. You can see how there is a huge amount of hidden energy costs included in the process. This wool has the GOZ certification (Global Organic Textile Standard), which is an extremely expensive certification and hard to obtain. Even we have tried to obtain it but it was almost impossible because of the costs and the overall complexity.

But this wool coming from Abruzzo could be truly GOZ certified. The wool comes from extensive organic farms, where the sheep live on pasture, feeding exclusively on the grass of the upland “Campo Imperatore” in Abruzzo. The sheep are then sheared, and they are no mulesing because in Italy there is no fly problem and we don’t use any kind of pesticides or antibiotics and these animals are healthy.

We then take this wool, wash it, and process it in Biella, under the classic standards applied in Italy. However, we are not able to obtain these certifications, even though the product is unquestionably sustainable.

Another important factor is the zero-kilometer production and the fact that everything is produced inside a really short supply chain

So, you can obviously distinguish between products that are certified and others that are not, but not necessarily the certified products are more sustainable than those that are not. There is still this problematic paradox.

This issue has been present for a long time and you can even think about the organic food industry. There is still not a unique organic certification, but there are many of them and all different. It is true that al lot of verifications are being done for the organic food, for

which they make samples and control whether there are present certain substances or not. But the problem is quite the same. There are many different standards and every country has its own rules, certifications and could be corrupt or not. Even here the blockchain can represent a huge opportunity if people are honest about the production process and the origin of every ingredient, but it is not obvious.

- What about your value chain? What are the main challenges of having a short supply chain and using Italian wool, instead of importing it? I assume the costs are higher as well as the workforce.

Exactly. Doing things in Italy is extremely costly from every point of view, but it's something we are proud of because the aim was to create a business where everything is close to its production process. I truly believe that the key to making something sustainable is having a short supply chain and creating this type of reality where people make a difference and are not exploited or underpaid. Proximity is the key to sustainability nowadays.

Our working system has been present in Italy since 1980. People can work from home and are paid fairly and this represents an additional income for them. They can work in front of the TV, during travels, or on vacation. We contribute to the economic well-being of the families in the valley and we make a good and important impact from the social perspective. It is all part of our way of working and being sustainable.

Then there is the issue of the wool supply chain in Italy, which is slowly dying. Some processes are not in use anymore, like carding and carbonizing for wool disinfection, and rarely anyone makes mattresses. The consequence is the wool discard, which represents a huge waste. Once it was quite different because the wool used to serve to make rugs, vests, and mattresses. However, all of this has basically disappeared.

We do not use the rough wool from the Alpago sheeps, because it is too coarse, but we have a collaboration with the wife of a shepherd in Abruzzo, who chooses the best wool feels and be able to obtain extraordinary results. The micron count of the wool was 21, which is a particularly relevant result for Italy and might be compared to Merino wool in terms of the feel you get while touching it. (The Micron count is a measurement for textiles, to evaluate the quality of the wool fibers and it marks the average diameter of a single fiber).

Thus, we are supporting the commitment and effort in central Italy to improve the quality of the raw materials. Even though the majority of these farmers raise their sheep for meat, they are starting to be careful about wool selection and starting to exploit fully this raw material and optimize the greasy wool.

They are doing a really good job and we are trying to collaborate with them to help each other and create even more value for the territory and the place we live in. These realities are slowly disappearing, and maintaining sustainability becomes difficult. The European legislation favors tourism, but it is hard to reach fully sustainable practices without these people that work the land and raise animal.

- Do you collaborate a lot with local producers and artisans?

Yes, absolutely. Our business is very small, so we can move quickly and adapt to these local realities. Our biggest challenge is dealing with the limitations that small businesses have. For example, every time we need to dye wool, the minimum quantities required are quite large, so we can't afford to offer ten colors for our products. Maybe we can only do four colors, which represents a limit for the production. Unfortunately, the capitalist system means that being small often results in higher costs for everything.

- Do you think consumers are becoming more aware of what they are buying, and are more interested in brands like yours?

No, I don’t think consumers are aware of that. There is growing attention towards sustainability, and everyone is trying to become more aware. However, the problem is that consumers buy what we tell them to buy. If we say that recycled polyester made in Vietnam is green, they will buy it, convinced they are doing something sustainable, and are even willing to pay more because they feel they are helping. It's very hard to have a clear idea. It’s difficult even for producers, so imagine how hard it is for consumers. We try to make internal assessments to understand the impact of certain products compared to others, but it's almost impossible to get a clear answer.

To be able to truly understand if one product is more sustainable than another, you would need to do a careful assessment of CO2 emissions. But even that measure is too limited. There are so many factors, such as ethical issues, and energy consumption, and it's not just about CO2.

So, what indicators should we use? We don't know. We all have vague ideas, and unfortunately, there is no desire to clarify things, because in this confusion, everyone can keep doing business as usual. Therefore, I am quite pessimistic about all of the issues and the "growing awareness" for sustainability. Right now, it all seems like "Greenwashing", starting with us.

When I reread the pages we wrote on our website ten years ago, I realize that some of it needs to be revised. For instance, we used to claim our socks were ethical because the wool was non-mulesing. Ten years ago, that might have been true, but now I have serious doubts about the reality and the verifiability of these certifications.

Because even when we contact some Chinese suppliers, they make it clear that if we want wool with a non-mulesing certification, they can provide it, but it's just a piece of paper. They don't know what kind of wool is in there. Certifications like RWS (Responsible Wool Standard) and others related to controlled supply chains seem like nonsense. Since these markets are largely managed by China, it's difficult to keep batches separate during processing.

- Would the solution be to have the control of the entire value chain?

Yes, we can do that with our Italian wool project, Manifattura Diffusa. It's a small project, but a beautiful one, and I hope it continues to grow. It will always remain small, which is fine. If there were many small businesses like ours doing similar projects, it would be fantastic. But large-scale operations like digital passports and such are purely commercial.

For example, the 'Virgin Wool' logo—no one wants it anymore. Back in the 1980s, it was popular. It looked like three interlocking rings, the symbol of Virgin Wool. It costs €40,000 a year to have that logo, and now no one wants it. But for many years, companies that wanted to certify their wool as virgin, meaning not recycled from other sweaters or products, paid for this label.

The same logic applies to green claims. You know that having this label attracts customers, so you're willing to pay for it. But whether it's truly sustainable is hard to tell.

- So it's all a lot of talk, and not much reality.

Yes, I believe so. I don't mean to say that it's all like this, but there is a lot of confusion. In this confusion, you can keep selling certain products, which otherwise would not be possible. If you wanted to be honest with yourself, it has to be done on a global scale. Is there really the will to do it? Because at that point, it's the same conversation we have about electric cars. They are marketed as being the best thing for the planet, but if you start looking at how the batteries are made, you realize that if everyone had an electric car, the planet would implode. So, it's all a bit of a marketing game, and the deeper you go, the more you realize it.

We didn't start our sustainable brand as a marketing strategy; we genuinely believe in it and try to be as transparent as possible. But we realize that sometimes, even what we say—certified or not—raises doubts.

Case Study 4

Interview Rifò

The idea of our brand and therefore what drove us to create a sustainable brand was born after a trip I have done in Vietnam where I worked for almost two years, when I realized that there was a problem of overproduction within the supply chain. I got the idea to go back to Prato and take up a Prato tradition, which is the regeneration of textile fibers.

95% of the supply chain is here in the district and the other 5%, 30 kilometers from us, starts from waste processing or old clothing.

They are then collected either directly by us or indirectly from our suppliers, which is then transformed into fiber, and yarn and then transformed into a new product by some processes that we have here in the area.

We have complete control of the production chain because it's all here in the area and this also allows us to have advantages both from an economic and environmental point of view that is above all fuel saving and all the impact of transport.

At the same time, it is also important to create job opportunities in the area, i.e. create lasting relationships with suppliers and also have ethical control of the supply chain almost weekly. Then we also have the presale model that allows us to have the local production because with pre-sales, we can make production very quickly in 3-5 weeks and we can do this because we have everything here, otherwise, that would be the transport.

We are now working on the circular service for traceability but we don’t use it continuously and have already given detailed information on the various garments.

An important document for us is the sustainability report, where we try to give all the information about the supply chain and our impact using technologies, especially on the logistics side, the warehouse, RFID, and warehouse management.

We are also against discounts and Black Friday because we don't believe in incentivizing people to consume more than they consume, therefore we believe that it is right that each person consumes what they need.

Everything has a value, it is impossible to think of a sweater today bought for 100 euros, and with Black Friday the sweater drops to 50 euros, so the question is “What is the value of the sweater? For us, it is very important to use that week to explain our values and what motivates us.