UNIVERSITÀ DELLA VALLE D'AOSTA
UNIVERSITÉ DE LA VALLÉE D'AOSTE

DIPARTIMENTO DI SCIENZE ECONOMICHE E POLITICHE

CORSO DI LAUREA MAGISTRALE IN ECONOMIA E POLITICHE
DEL TERRITORIO E DELL'IMPRESA

CURRICULA IMPRESA E MERCATO

ANNO ACCADEMICO 2021/2022

TESI DI LAUREA
TRACEABILITY ALONG THE SUPPLY CHAIN: A FOCUS ON BLOCKCHAIN TECHNOLOGY

RELATORE:
Prof. Giampaolo VIGLIA

STUDENTE:
Giulia GIROTTO
Mat 20G01250

Table of contents

Introduction

Traceability along the supply chain is an issue which is gathering greater relevance for firms located in very different industries. In the last three decades we assisted to a massive increase in offshoring and outsourcing[1], especially towards less developed countries. This tendency progressively led companies to a fragmentation of their supply chains with phases performed all over the world. Nowadays there is a growing request, coming from the increased awareness of consumers and from international standards as well, of transparency and clearness. Hence companies are requested to have their supply chains traceable and available to every stakeholder, from shareholders to final consumers. The fashion industry and the food industry are two examples of industries dealing with this increased need for traceability.

Clothing is one of the largest industries in the world economy, with annual revenues of around 3 trillion USD, producing 80 billion garments, and employing 60 to 75 million people with direct jobs in every part of the globe[2]. In this framework, the industry is in an interesting position, with few companies committed to social or environmental issues and transparency. The biggest share of fashion companies is not addressing these problems, but it is rather arranging marketing campaigns relying on environmental themes without implementing real and significative actions. This phenomenon is known as greenwashing, and it is one of the biggest challenges for companies really acting in the environmental and social field.

Traceability is a crucial issue also for food industry from a health and security perspective and from a responsible and sustainable consumption standpoint. Consumers are more and more aware when it comes to the purchase of food products, and they apply many standards when choosing a product rather than another. Consumers want safe and nutritious food,

[1] Timmer M.P., Los B., Stehrer R. et al. (2021), Supply Chain Fragmentation and the Global Trade Elasticity: A New Accounting Framework, *IMF Econ Rev* 69: 656–680.
[2] United Nations Economic Commission for Europe (2017), *Transparency in textile value chains in relation to the environmental, social, and human health impacts of parts, components and production processes*, Geneva: UNECE.

possibly coming from organic producers or a socially responsible farm[3]. This market request makes traceability a fundamental requirement for every company in the food industry.

Blockchain makes the perfect tool to address this new need and satisfy traceability demand both for consumers and producers. Since its appearance on the market fifteen years ago, this technology has gained great attention for its use in the cryptocurrencies market, but its importance resides in its features. Using Blockchain for recording data and processes allows for the creation of a reliable and immutable ledger of information.

[3] Food traceability guidance, FAO, 2017: https://www.fao.org/3/i7665e/i7665e.pdf

1. Traceability

1.1 Definition of Traceability

Traceability can be defined as the ability to trace the application, location, and/or history of an activity or item by means of recorded data[4]. Traceability can also be assessed as the ability to identify and verify the components and chronology of events in all steps of a process chain[5]. Applying the concept of traceability to of supply chain processes implies that every process undertaken by the different players must be traceable and trackable. Achieving a high level of traceability strongly depends on the complexity and the articulation of the supply chain. Highly complex supply chains, involving many actors located worldwide, can impede the achievement of a fully traceable supply chain in absence of an efficient tracking technology.

Traceability can be analyzed by considering two different ideas, which may appear similar and are often confused: the ability to track and the ability to trace. Tracking refers to the procedure of acknowledging the location of an item in the supply chain according to some pre-defined criteria. Tracing is the procedure of discovering the origin and the characteristics of a certain item from some given criteria. The ability of tracking allows for the inspection of non-conforming items while tracing is necessary to investigate the causes of such unconformity. It is necessary to develop systems which are at the same time able to track and trace, since effective tracking does not imply effective tracing, and vice versa.

Traceability systems can be analyzed looking at three attributes because every traceability system has different degrees of breadth, depth, and precision[6]. Breadth is defined as the amount of information that is

[4] Traceability: http://www.businessdictionary.com/definition/traceability.html

[5] Skilton P.F., Robinson J.L. (2009), Traceability and normal accident theory: How does supply network complexity influence the traceability of adverse events? *Journal of Supply Chain Management, 45*, 6: 40–53.

[6] Olsen P., Borit M. (2018), The components of a food traceability system, *Trends in Food Science & Technology*, 44, 77: 143-149.

collected throughout the system. The extent of collected information can vary in the different stages of the supply chain since each passage can add new features and related information or discard old ones. For example, in the process of refining coffee the attribute of caffeine can be discarded and the attribute decaffeinated is added. The attribute of depth measures how far back a system keeps track of an item attributes. Often system breadth creates preconditions for having a satisfying system depth. Precision of a traceability system refers to the degree to which the system can identify a specific TRU[7]. Breadth, depth, and precision of a system are inherently linked but enhancing one of these parameters increases the amount of information recorded but it can easily become a costly process. For this reason, it is necessary to evaluate the impact of implementing these three dimensions on the economic and/or performance yield.

1.2 Traceability and Transparency

It is necessary to specify that increased traceability does not immediately and directly imply increased transparency, especially if the supply chain is made of few players with loose relationships. At the same time, the optimization of traceability and transparency are highly correlated. Transparency can be defined as the extent to which information is readily available to both counterparties in an exchange and at the same time to outside observers. In a supply chain context, transparency refers to information available to companies involved in a supply chain network according to Awaysheh and Klassen[8]. The information shared between two or more organizations can be classified based on its transparency into three levels defining different communication styles. Communication can be opaque, when no information is shared between the parties neither for daily operational activities. The middle level is translucent communication, where

[7] TRU is the traceable resource unit, and it is a unit with a unique identifier that can be tracked or traced in a supply chain.

[8] Awaysheh A., Klassen R.D. (2010), The Impact of Supply Chain Structure on the Use of Supplier Socially Responsible Practices, *International Journal of Operations and Production Management,* 30, 2: 1246–1268.

only outline information, such as interface conditions and partial data, is shared. The deepest level is transparent communication where information is shared on a selected and justified basis. Transparency in information leads to shared knowledge and development of collaborative abilities between the parties.

The relationship between traceability and transparency is not forthright because having an increased transparency may lead to an increase in traceability while increased traceability may not imply increased transparency if the supply chain is made of few participants and communication inefficiencies are common. Therefore, it is necessary to develop a well-functioning traceability system which must be supported by transparency driven behaviors.

1.3 Supply chain

A supply chain is the network of all the individuals, organizations, resources, activities, and technologies involved in the creation and final sale of a product, starting from the delivery of source materials from the supplier to the manufacturer, through to its delivery to the end user[9]. The number of players involved in the supply chain can vary, depending on the complexity of the product and on the extension of the product lines. The actors in the case of a retail supply chain are linked together through the physical flow of products from producers to end consumers.

Nowadays, it is frequent to find the different steps of the supply chain located in different parts of the world. This delocalization of the production process and subsequently of the supply chain can be caused by different factors, the more significant ones can be identified in cheaper labour, higher availability of raw materials or less strict regulations. In this framework, Supply Chain Management (SCM) becomes a crucial activity since its goal is to organize and address the flows of materials, information, and finances.

[9] LeMay S., Helms M.M., Kimball B., McMahon D. (2017), Supply chain management: the elusive concept and definition*, The International Journal of Logistics Management*, 28, 4: 1425-1453.

The flow of information is the core element for all the traceability-related issues. Until the end of the 80s, all the activities of the supply chain were performed one close to the other and information were all easily collected and stored at a central level. Supply chain resulted as a quite simple linear process following a definite sequence of steps. During the so called "Supply chain revolution" of the 1990s, individual enterprises became part of larger networks that evolved from independent units to integrated supply chains[10]. Nowadays it is necessary to develop efficient strategies in Supply Chain Management to integrate company's operations with environmental practices and to implement a traceable system of activities.

During the last two years of pandemic global supply chains faced many difficulties lacking the products of one supplier or not having available raw materials. This period brought up the fragility of these systems and therefore some companies decided to go for reshoring[11]. Reshoring could be a great strategy also for traceability purposes because information within the same area can be easily registered and checked but at the same time it is not possible to bring back to the home country all the activities of a supply chain.

1.4 Institutional background

The rising awareness around traceability-related issues has also drawn the attention of national and supra-national authorities. In particular, the UN set up in 2015 the *Sustainable Development Goals*[12], a set of 17 global goals to be achieved by 2030[13]. They were set as broad and independent goals, but the UN soon identified some specific targets to make them more actionable and measurable. For each of the 17 goals a list of 8

[10] Simatupang T., Sridharan R. (2003), The Collaborative Supply Chain: A Scheme for Information Sharing and Incentive Alignment, *The international journal of logistics management*, 46, 3: 102-125.
[11] Reshoring supply chains: https://www2.deloitte.com/us/en/insights/industry/public-sector/government-trends/2022/reshoring-global-supply-chains.html
[12] Referred as SDGs
[13] Sustainable Development Goals: https://www.un.org/sustainabledevelopment/sustainable-development-goals

to 12 target is defined. There are different tools to track and measure each target to make data available and easily understandable. The SDG Tracker[14], for example, is a set of indicators based on reliable statistics from the UN and other international organizations. The 17 goals are listed in Table 1.1, and they cover a broad set of themes from human wellbeing to economic growth and climate action. Before setting the SDGs, the UN Global Compact already defined supply chain sustainability as a priority including traceability as one key element of the system.

Traceability can be a natural consequence of many goals: following the targets almost automatically leads to a more traceable supply chain and at the same time undertaking traceable practices means achieving some SDGs. The *Climate action goal n.13* is focused on actions to address climate change. Goal *n.8 Decent work and economic growth* promotes development-oriented practices to support productive activities. Other SDGs like Goal n.6, n.14 and n.15 are focused on water, energetic efficiency and therefore they make a great starting point to become a fully traceable player. The last SDG *Partnership for the goals (n.17)* underlines the need for measuring progress on sustainable development of existing initiatives or new ones. This target is about the need for traceability with a focus on measurement and recording of actions along the whole supply chain. The SDGs also make a good starting point for the creation of international certifications or traceability-related programs.

2. Technologies for Traceability

Supply chains have significantly transformed themselves, not involving anymore linear processes made up by well-defined subsequent steps. Due to this evolution, it is evident that new systems must be developed and implemented to cope with this greater complexity. Technology becomes a fundamental and necessary tool to deal with such

[14] SDG tracker: https://sdg-tracker.org/

articulated supply chains from a logistic perspective as well as from a traceability perspective.

2.1 Barcodes

Barcodes represent the traditional tracking system that is attached to the label of products. They are symbols that can be scanned using laser or camera-based systems[15]. They are used to encode information such as serial numbers, product numbers or batch numbers and for this reason they play a key role in the supply chain since they make it possible to immediately and automatically identify a product. Nevertheless, barcodes offer restricted possibilities for traceability purposes, especially in terms of data storage. Nowadays, it is possible to identify different and more advanced tracking technologies to implement and improve the quality and the quantity of information linked to a single product and its history, thus leading to an increased traceability along the supply chain.

2.2 Internet of Things

Internet od Things, commonly addressed as IoT, is the technology which allows objects to communicate on the Internet. Items which employ Internet of Things are for example cell phones, washing machines, headphones, lamps, or wearable devices. All these items are designed with a consumer perspective because they lead to the creation of a highly customized smart consumer experience, but the Internet of Things can also have a huge impact on the supply chain. The Internet of Things can smartly connect people, processes, data and things through different devices or sensors, thus leading to a completely different model of Supply Chain Management. Some examples of the benefits brought by the application of the Internet of Things technology in the supply chain are a reduced asset loss since problems and issues are immediately spot and solved; greater user insights thanks to the sensors which provide information on product

[15] Huber N., Michael K., McCathie L. (2007), *Barriers to RFID Adoption in the Supply Chain*, 1st Annual RFID Conference Eurasia, 1-6.

usage and consumer behaviour; efficient management of the warehouse stock[16].

It is possible to identify three main ways in which the Internet of Things affects the supply chain:

a) Efficiency. Internet of Things makes things and information which were once invisible into visible ones. This allows supply chain managers to have a complete overview of the different processes and to precisely locate items along the supply chain. This increased amount of data available to managers allows them to effectively deal with variation and rather than eliminating it, using it as a foundation for competitive advantage or as a driver for innovation. This process takes place inside the company and sometimes can be limited since efficiency can be increased only towards a certain level.
b) Differentiation. Internet of Things allows the shift from a more traditional push approach towards a pull approach. Sensors attached to products provide the managers with clear information on where the items are located and provides an overview of consumer's habits. From a supplier perspective, companies include suppliers and distributors into an end-to-end system, with pull-driven order systems. From a consumer perspective, companies do not push anymore their products along the value chain to their end-users, but they can rather gather information from them and identify more accurate segments and differentiate or customize their products.
c) Innovation. As already mentioned, the significant amount of data brought in by Internet of Things technologies leads to an efficient exploitation of the variation in the supply chain instead of the search of techniques for suppressing it. This tendency pushes a company to create a unique ecosystem enshrining all the players involved in the supply chain, generating new business models. One interesting

[16] Brous P., Janssen M., Herder P. (2020), The dual effects of the Internet of Things (IoT): A systematic review of the benefits and risks of IoT adoption by organizations, *International Journal of Information Management*, 51.

example is to transform the supply chain from a cost center to a revenue generator.

The benefits brought by the Internet of Things are all concerned with and deriving from flows of information. The production of these information can be shared with all the stakeholders of a company to assess transparency and demonstrating that the company follows a traceable path in its production process. Combining IoT with other technologies such as Blockchain allows for the implementation of efficient traceable systems.

2.3 Digital identity

Digital identity is an authentication system used for transactions and communications, especially online, and it can be associated with people, groups, organizations, or items. The Digital Identity systems use anonymous and dynamic data that cannot be stolen or lost [17]. The immediate consequence of the employment of a digital identity in a transaction is the decreased level of risk and the subsequent increased trust among parties involved in the transaction. In fact, there are some pre-defined standards and requirements to obtain a digital identity. The features to be entitled of a digital identity are not internationally standardized but they can vary depending on many factors and local regulations.

In the framework of supply chain, Digital Identity becomes fundamental since every actor involved in the chain needs to have his own digital identity to be trusted and to participate in a transaction. At the same time also the suppliers and the items moving along the supply chain need to have a digital identity to precisely track their locations and their source.

[17] Martinez-Julia P., Gomez-Skarmeta A.F., Girao J. and Sarma A. (2011), *Protecting digital identities in future networks*, Future Network & Mobile Summit, 1-8.

2.4 Smart tagging technologies

Smart tagging technologies are electronic tags attached to an object for the purpose of tracking or storing data related to its use and origin[18]. These technologies are in the field of Internet of Things. The most widespread smart tagging technologies are Radio Frequency Identification, also known as RFID, Near Field Communication, also known as NFC and Quick Response Codes, also known as QR codes.

The Radio Frequency Identification (RFID) technology is based on smart tags and uses electromagnetic fields to automatically track and identify tags attached to objects. The tags contain electronically stored information. RFID tags can be used in very different industries and can be attached to cash, clothes, possessions or implanted in animals for example. They are already employed by companies for logistics reasons or for easily gathering information from suppliers and retailers. The application of RFID tags can be enlarged also to the purpose of tracking and monitoring all the activities along the supply chain with the aim of achieving transparency, rather than only assessing logistics efficiency.

Near Field Communication (NFC) is a short-range wireless technology which allows data transfer between two devices. Due to its specificities, it is more suitable for situations in which a physical touch or close distance is needed.

Quick Response Codes, better known as QrCodes, are another tool for achieving traceability along the supply chain. A QrCode is a two-dimensional barcode, consisting of an array of black and white squares, typically used for URLs or information storage which is readable by the camera of every smartphone.

Blockchain is the last technology used to assess traceability along the supply chain and it will be discussed in detail in the next chapter.

[18] Kirch M., Poenicke O., and Richter K. (2017), RFID in Logistics and Production – Applications, Research and Visions for Smart Logistics Zones, *Procedia Engineering*, 178: 526-533.

2.5 Issues for the implementation of traceability technologies

Having analyzed the different technologies helping to assess traceability along the supply chain, it is necessary to also look at the possible threats arising from the application and implementation of the above-mentioned technologies. To implement an efficient advanced tracking system, a company needs to develop or purchase the technology, to standardize and harmonize all the actors in the supply chain and eventually the development of such systems requires a great financial investment.

It is possible to identify four main obstacles[19] to the powerful adoption of traceability technologies:

a) Costs have been largely identified as the main barrier to the adoption of advanced tracking systems in the past decades. Nowadays this assertion is not anymore true since for example the cost of basic RFID tags is below 0.05€[20]. The only industry which is still facing cost barriers is the agricultural one. Often agricultural products have on average a price well below 1€[21] and therefore the cost of a tag is not sustainable for most of the farmers. Moreover, RFID tags attached to agricultural products should also be more resistant than usual ones since they must operate in colder and more humid conditions, in order to keep the food fresh.

b) Harmonization and standardization are the second issue related to the adoption of advanced tracking technologies. To have a well fucntioning and deeply efficient technology for tracking it is necessary to have homogenous data, complying with national regulations, and well-functioning communication infrastructures for the technologies. Advanced tracking systems need to be able to work across companies, sectors, and countries. International regulations and

[19] Sarpong S. (2014*),* Traceability and supply chain complexity: confronting the issues and concerns*, European Business Review*, 26, 3: 271-284.
[20] Evolution of RFID: https://www.abr.com/evolution-of-rfid/
[21] FAO food price index: https://www.fao.org/worldfoodsituation/foodpricesindex/en/

legislations are a powerful tool to create international standards which are the base for the implementation of a homogenous network.

c) Security and privacy issues are a threat for the implementation of advanced tracking technologies. Security and privacy concerns refer to the existence of illegitimate sources of data or the presence of illegitimate readers of the data. Privacy issues are more relevant for a consumer perspective since with the breach of unauthorized readers, an information leakage can occur, and sensible information are stolen and revealed.
d) Lack of skilled workforce to support and overcome the increasing demand is a barrier for the large development of advanced tracking technologies. Engineers and IT specialists prefer to address themselves and their skills to more secure and traditional sectors and to business to consumer companies, rather than business to business activities.

3. Blockchain Technology and Traceability

Blockchain technology is mainly known for his large application in the financial sector, especially with regards to cryptocurrencies. However, companies are showing an increasing interest in the introduction of Blockchain along their supply chains. In fact, Blockchain is a powerful and effective tool to assess transparency and gain along the supply chain.

3.1 Cryptography

To analyze the Blockchain technology, it is necessary to explain what cryptography is and how it works since Blockchain is based on such technology. Cryptography is a method of storing and transmitting data in a particular form so that only those for whom it is intended can read and process it. In the cryptographic encryption process there are different players, and each of these players has his own set of keys[22]. Cryptographic

[22] Katz J., Lindell Y. (2021), *Introduction to Modern Cryptography*, Boca Raton: CRC Press.

encryption can be either public or private. When it is public, others can create an encrypted message which can be read only by the player - owning a set of keys - and they can verify a signed message. Private encryption is employed by the player - owning a set of keys - to sign messages and decrypt or read other messages encrypted with the public key.

There are some hashing functions used for message digest. Basically, the hashing operations produce a much shorter digest – hash – of a document or data. Once original data or documents have been hashed, they cannot be reconstructed if their input data are unknown. This feature is fundamental since the peculiarity of Blockchain is that once an information becomes part of the Blockchain it cannot be modified nor deleted.

3.2 Functioning of the Blockchain technology

Blockchain is an open source, decentralized and distributed database for sharing transaction information or tracking assets in a business network[23]. The assets, and their transactions, can be either tangible such as a garment, a car, or cash, or either intangible such as intellectual property, patents, or copyright. This technology is based upon a network of peers which maintain copies of one truthful ledger rather than relying on a centralized intermediary and they can verify, send, and receive transactions. The ledger contains all the information regarding confirmed transactions since Blockchain creation. This ledger is replicated in several copies among computers in the peer-to-peer network, the so-called *nodes*. When a new transaction occurs, it is recorded as a *block* of data. New elements are appended to the end of the Blockchain using the hash-digest of the previous block within the current block and they cannot be modified nor deleted. Once the new block is attached to the blockchain the transaction is completed[24]. Figure 3.1 provides a scheme for a better

[23] Blockchain: https://www.ibm.com/topics/what-is-blockchain
[24] Yim J., Yoo H. Kwak J., Kim S. (2018), Blockchain and consensus algorithm*. Electron. Telecommun. Trends*, 33: 45–56.

understanding of the functioning of Blockchain Technology[25]. Each block can record different kind of information: location, temperature, time, conditions of an asset are only few examples of what can be recorded. A consensus algorithm guarantees continuous information consistency among different copies of the ledger.

The whole Blockchain system allows for a secure storage and truthful maintenance of data and documents. No participant in the blockchain network can change a transaction after it has been recorded to the shared ledger. If a transaction contains wrong information or errors, a new block must be added and eventually the two transactions remain visible. Nevertheless, it is necessary to specify that security does not imply nor mean privacy. In fact, many Blockchain implementations consider data to be public, as for example Bitcoins[26]. In conclusion, Blockchain allows for the creation of valuable networks with more users (interoperability property), characterized by more transparent transactions with respect to those provided by centralized systems.

3.3 Blockchain and Supply Chain Management

Analyzing the four key supply chain pain points, it is possible to see how Blockchain can remediate them:

a) Traceability. As already mentioned, it is not easy for a company to monitor all the events and meta data associated with a product. Blockchain provides a full audit trail of data, creating an everlasting means of record keeping along a supply chain. This allows the company to inspect non-conforming products and the causes for noncompliance.
b) Compliance. Every company has to prove that standards and regulatory benchmarks are met. All the transactions involved in the Blockchain are recorded and cannot be changed and therefore create

[25] The scheme was reproduced from Abirami R.S. and Muthuswamy P. (2022) *Influence of Blockchain Technology in Manufacturing Supply Chain and Logistics*, Logistics, 6, 15.
[26] This Blockchain is defined as Public Blockchain Network. There are also Private Blockchain Networks or Permissioned Networks.

an integer unique source of data. This can prevent a company from paying fines for non-compliance with the regulatory framework in which it operates.

c) Flexibility and efficiency. The concept of flexibility implies the ability to rapidly adapt to issues or unexpected events without significantly increase the operational costs. Blockchain allows for the creation of smart contracts which provide a continuous real-time tracking of data. Smart contracts are set of rules that are automatically executed and therefore allow for time saving and increased efficiency.
d) Stakeholder management. Companies should implement an effective corporate governance to assure effective communication, reduce the risk and establish trust among the involved parties. Blockchain allows for a trusted peer-to-peer network in which interactions are trusted based on the digital signatures.

3.4 Blockchain and Traceability

Every product has a long history but much of this story is presently obscured or unknown for the different players in the supply chain and for final consumers. Blockchain technology can be applied to record information along the supply chain in every industry, from the textile to the agricultural to the iron and steel. The use of Blockchain makes it possible for every company to record all the information, processes, transformations, and transactions applied to their products, starting from the raw materials to the final delivery to retailers or end-users[27].

This increased shared amount of information will benefit all the stakeholders of a company, but the biggest beneficiary in the long run will be the final consumer. The flow of information and data available will facilitate a power shift from the retailer to the consumer, with a significant reduction of intermediaries between the end-user and the producer. This

[27] Justin S., Naveen U., Madhusudanan P. (2020), Supply chain transparency through blockchain-based traceability: An overview with demonstration, *Computers & Industrial Engineering*, 150.

enormous amount of data also creates trust, allowing the consumer to deepen the history of a product and eventually developing a bond with the company producing it. Increased traceability has also an impact on marketing strategies because it leads to higher engagement rates and conversion.

4. Fashion Industry and Traceability strategies

Clothing, as already mentioned, is one of the largest industries in the world economy, generating annual revenues of around US$ 3 trillion, producing 80 billion garments, and employing 60 to 75 million people with direct jobs worldwide[28]. The fashion supply chains operate in global value chains and companies decide what to produce, how to produce it, when to produce and at which prices to sell the final product.

4.1 Fashion supply chain

Fashion industry demands fast, accurate and agile supply chains. In the fashion supply chain there are different stages, linking the source of raw materials, to the factories where these raw materials are transformed into garments and eventually to the distribution network to reach the final consumer. The complexity of fashion supply chains can vary depending on the type of product, the availability of raw materials, the number of players involved and the different versions of a product. It is possible to group the activities performed along a fashion company supply chain under five main groups. The five main steps of a fashion supply chain[29] can be identified as:

a) Design is the first stage, and it includes the definition of details of fabrics, silhouettes, trims, and finishes. This stage is performed at a company level because designers are the heart of fashion companies.

[28] UNECE Research Paper (2017), *Transparency in textile value chains in relation to the environmental, social, and human health impacts of parts, components and production processes*, Conference on ethical and informed choices for sustainable clothing

[29] Nagurney A., Yu M. (2011), *Fashion Supply Chain Management Through Cost and Time Minimization from a Network Perspective*, Fashion Supply Chain Management: Industry and Business Analysis, 1 – 20.

Moreover, design is the distinguishing feature of every company, and it represents the company's identity and signature. For these reasons, design always takes place at a central level.

b) Material production involves the creation or growth of the raw material, the spinning into a fiber, the weaving into a fabric, the dyeing and eventually the finishing. The raw materials can be grown, as in the case of cotton or linen, or they can be chemically created in a laboratory, as in the case of lyocell, polyester or nylon. When dealing with grown raw materials and subsequent natural fibers, both the growth and the spinning stage are often performed in another country compared to the main place of business of the company. The largest natural fiber producers are China, Pakistan, India, US, and Brazil[30]. The biggest producers of chemical fibers worldwide are China, Taiwan, and Eastern Europe. The subsequent phases of weaving, dyeing, and finishing of chemical raw materials are performed in the same countries where the materials are created or sent to. Therefore, the material production phase is in the majority of cases performed in the above-mentioned countries, which usually do not correspond to the place of business of fashion companies, mainly located in Western countries. This phase of the fashion supply chain is particularly critical for traceability issues because many transformations and processes are performed.
c) Clothing production involves the cutting, sewing, and finishing of a garment. Once this phase is concluded, the piece of clothing is packed, and it is ready for shipment towards distribution centers.
d) Distribution and retail include all the worldwide transportation needed to reach the distribution points and eventually the different retailers.
e) Consumer phase is the last step of the fashion supply chain, and it is characterized by the consumer usage of the garment, the laundering

[30] Cotton production: http://www.schededigeografia.net/geografia_economica/cotone

of the product and the end of product use. This last step, even if not directly performed by the company, has a great importance.

4.2 Reasons for traceability in the fashion industry

With the deep growth in the number of fast fashion companies, the number of garments produced every year and subsequently sold has deeply increased. Along with this increase, a decrease in the average life of a piece of clothing has decreased, leading the average lifespan of a piece of clothing to 2.6 years[31]. The shorter average age of garments may be due to three factors: lower quality standards, market trends of consumerism and a change in the industry with brands releasing on the market monthly or even weekly collections. All these factors combined had and still have a negative impact on the environment as well as on working conditions, sometimes leading to tragedies[32]. These facts, such as the Rana Plaza disaster occurred in April 2013[33], draw the attention of different worldwide players and stakeholders of fashion companies. Together with this rise in awareness, technological development has given fashion companies the tools for implementing transparency in an efficient and reliable way.

In the fashion industry Blockchain can support the transition from linear supply chains to circular models. Moreover, Blockchain can lead to the implementation of traceable systems where all the information is available to consumers and stakeholders. At the same time, such system can guarantee that minimum standards in working conditions are met given that everything has to be registered on the Blockchain. Increased traceability by using Blockchain provides a wide spectrum of benefits, from economic to social.

[31] Klepp I.G., Laitala K., Wiedemann S. (2020), Clothing Lifespans: What Should Be Measured and How, *Sustainability*, *12*, 6219.

[32] Rinaldi F.R., Di Bernardino C., Cram-Martos V., Pisani M.T. (2022) Traceability and transparency: enhancing sustainability and circularity in garment and footwear, *Sustainability: Science, Practice and Policy*, 18, 1: 132-141.

[33] Rana Plaza disaster occurred on 24th of April 2013 in Dacca, Bangladesh. A building of a textile factory collapsed, and 1138 workers lost their life.

4.3 Case study: Martine Jarlgaard London

Martine Jargalaard London[34] is the first and most relevant example of fashion brand actively using Blockchain. She is an artist, a visionary, an activist, and a fashion designer, Forbes defined her a technology pioneer in the fashion industry[35]. Before approaching Blockchain she has always been deeply committed to sustainability, carefully picking her fabrics such as recycled plastic fabric, peach silk or chrome-free leather produced by a refugees NGO in Turkey. She has always been really selective in the choice for her suppliers and collaborators. By the end of 2018, she narrowed the number of her suppliers down to five. Her great attention and commitment led her to Provenance and their Blockchain-based technology. With Provenance she managed to merge her attention for sustainability with technology, becoming a disruptive brand in the worldwide panorama of fashion companies.

4.3.1 The Technology: Provenance

Provenance is a platform designed to enable companies to take a step towards digital innovation, efficiency, and transparency. They work with businesses to make their supply chains and the impact behind products transparent. As of today, Provenance provides solutions for three industries: fashion, beauty and wellness and food and drinks. To achieve transparency Provenance came up with a software and a framework – called Provenance Framework – to easily communicate the social and environmental impact of brands using their system. The Provenance Software is made by different tools allowing a company to communicate in a credible way by sharing proof points – often recorded on blockchain – or third-party certifications. They also create interactive maps of suppliers in the supply chain along with a description of each company. The Software also provides product journeys which allow the shopper to identify

[34] Martine Jarlgaard: https://martinejarlgaard.com
[35] Martine Jargaalrd: https://www.forbes.com/sites/rachelarthur/2017/05/10/garment-blockchain-fashion-transparency/?sh=70ba205f74f3

suppliers, processes, and ingredients in a timeline. At each step of the journey, claims and certifications are added to provide assurance. The Provenance Framework identifies different credible claims organized in five categories: *climate, waste, nature, workers,* and *communities*[36]. For each group there are different tags along with an explanation. These tags may refer to existing certifications and awards or they are definitions created by Provenance to identify a certain process undertaken by the company. The existing certifications come from various sources such as non-profit organizations, consulting firms, local governments, or NGOs. Looking at Table 4.1 it is clear that *nature* and *workers* groups frequently refer to international certifications. These two themes make up the first points of interest and awards assigned to firms in terms of traceability and environmental and working standards. The *communities, waste* and *climate* groups are mostly focused on definitions provided by Provenance itself because the areas lack of certifications. The tags defined by provenance are inspired by the Sustainable Development Goals. The *climate* group refers to the Climate Action Goal, the waste group refers to the Sustainable Development and Production Goal, the nature group refers to the Life on Land Goal, the Life Below Water Goal and Zero Hunger Goal, the community group refers to the Decent Work and Economic Growth Goal and No Poverty, the community group refers to Reduced Inequality Goal and Good Health and Well-being goal.

There are different benefits reported by brands using Provenance[37]:

a) Higher quality of marketing contents thanks to the Proof Points and the storytelling about the product, its production and history
b) Increased conversion rate of shoppers clicking on the Proof Points or on the timeline of the product
c) Time saving due to the standardization provided by the Provenance Framework which allows to classify and tag different type of products and even brands always using the same scheme

[36] Provenance framework: https://www.provenance.org/framework
[37] Provenance results: https://www.provenance.org/case-studies/cult-beauty

All the information of the Provenance Technology and Provenance Framework are recorded on the Blockchain, thus achieving reliability and credibility.

4.3.2 Traceability system

In 2018 Provenance and Martine Jargalaard started their collaboration. By that time Provenance only dealt with food companies and at the same time the fashion brand was implementing sustainable actions but lacking technology to support its activities. To create a Blockchain based transparent supply chain Martine Jargalaard had to create a Provenance account and so had to do her suppliers. Every player in the chain, the final brand, and the suppliers pay a monthly fee to Provenance. Given that the designer carefully picked her suppliers, it was not hard to convince them to enter this new system. All the information is packed in a wash-proof chip stored inside the clothing. This chip is usually located on the label, and it can directly be scanned with a phone unlocking a link containing the clothing's journey. The access to the link is through a QR code or NFC placed on the label[38]. The link can easily be shared online and contains both technical and more "emotional" information. An example of the different kind of details shared are the time of delivery of a certain piece or the story about the community where a certain item was produced. Once the garment is sold, the final consumer can add himself to the chain maintaining alive the history of the piece. This prosecution of the history creates a great opportunity for future resale in the vintage or pre-owned market. Having a full history of all the owners makes it possible to determine the right price and value of the garment.

The use of Provenance blockchain-based technology allows from benefits for many stakeholders. Consumers are always more curious, and

[38] Bezovski, Zlatko, Jovanov, Tamara, Temjanovski, Riste (2021), The Impact and the Potential Disruption of the Blockchain Technology on Marketing, *Journal of Economics*, 6, 1: 13-23.

they are willing to make informed choices towards sustainable brands. With this system they can without effort access all the information, from the raw materials to the designer's studio in London. The second group benefiting from this system are the suppliers and all the players involved in the supply chain. Their abilities and histories are available for everyone, and this contributes to make them trustworthy as well. At the same time also, new suppliers can easily gather information about the brand, its standards, and its way of working. Buyers as well can learn all the details of every piece and make more complete proposals to clients.

The brand itself can of course profit from the use of Provenance technology. The first point is credibility: this technology makes the company reliable and trustworthy in the eyes of consumers and all the other stakeholders. Along with credibility goes transparency, a fundamental requirement to obtain certifications, achievements, or international tags. The use of technology in the fashion domain may also attract new clients or collaborators, interested in the innovative system. Many clients of Martine Jargalaard London acknowledged that they did not know the brand before the introduction of Blockchain and that the technological part was the element drawing their attention[39].

5. Food industry and Traceability

Food industry has been dealing with traceability for longer than other industries, compared with fashion for example. This longer tie with traceability issues and standards is due to safety concerns. Food safety is a primary requirement, and the lack of such requirements can lead to bacteria, viruses, parasites, and intoxication from chemicals[40]. At the same time an increasing demand on the demand-side for quality and production

[39] Martine Jarlgaard and Provenance technology: https://www.forbes.com/sites/oliviapinnock/2018/07/25/meet-the-first-fashion-designer-to-adopt-provenances-blockchain-technology/?sh=612484fa7ad6

[40] Food safety: https://www.who.int/news-room/fact-sheets/detail/food-safety

standards has led the industry to consider traceability as a central point in their supply chains.

5.1 Food Supply Chain

Food supply chains have become more and more similar to other supply chains: they are global and fragmented. The number of stages can vary a lot depending on where the raw material is sourced, if some processing stages are required and if the products need a packaging. Even if the different stages can vary depending on the type of product it is possible to break down the food supply chain in five stages[41]:

a) Production is the stage where the food is grown, cultivated, or developed. This phase is led by producers who need to operate under national and/or international standards[42]. Producers can be either farmers, food manufacturers or animal farmers. Production almost always occurs on a different location, often another country, with respect to the home country where the food company has its headquarters.

b) Processing and packaging stage involves all the transformations of the primary ingredient. During this phase ingredients are mixed, refined, cleaned, processed, cooked to be ready for packaging. Similarly to production, also this phase is subject to many regulations and operational standards. Such standards are necessary for products to be sold on the market especially in terms of food safety as for example in the case of pasteurization of milk. Such requirements may come from local governments as well as from final retailers who demand high quality and good-looking food. Once the processing is done, the food is ready for packaging. The goal is to preserve food in the best possible way in order to reach the final consumer almost unaltered. Also, in this phase

[41] Ahumada O., Villalobos J.R. (2009), Application of planning models in the agri-food supply chain: A review, *European Journal of Operational Research*, 96, 1: 1 – 20 .

[42] International standards are for example the General Food Law Regulation established by the European Parliament

there are standards for the packaging materials to avoid food contamination and in order to deal with environmental standards. Usually, this phase is performed in the same country where the production occurs or in adjoining countries.

c) Distribution and retail are the longest phase in the food supply chain. Packed food is transported towards distribution centers and eventually delivered to final retailers. Packed food is often transported by ship, but fresher products can be transported by air. Food Miles[43] assess the distance covered by a product from the producer to the final consumer and they provide a measure of the environmental footprint of the whole supply chain. This metric is higher when the product comes from a distant country, but it also depends on the type of transport. For a given distance, sea freight has a lower impact compared to air transportation. The final part of the distribution phase is usually operated by road transport to reach retailers such as supermarkets, malls, convenience stores.

d) Consumption is the last phase in the food supply chain, and it occurs when the final consumer buys a product and eats it. Consumption phase can be at home or at a restaurant.

It is important to mention an issue which can arise throughout all the different steps of the food supply chain: food loss and food waste. Food loss occurs in the first part of the supply chain, during the production or the processing and packaging. It is usually caused by inefficiencies along the supply chain like poor infrastructures, lack of technology, logistic problems, and long time to reach market. Food waste mainly refers to the last two phases of the supply chain and it takes place in distribution and consumption. It occurs when food is discarded due to its expiration date, both at retailer and consumer level, or when food is inaccurately stored and preserved. Both food loss and food waste reduce the amount of food

[43] Renata O., Garcia C., Góes Pinto P. (2020), Accessibility to Food Retailers: The Case of Belo Horizonte, Brazil, *Sustainability*, 12, 7: 2654.

disposable for final consumers and can lead to higher prices as well as increased levels of pollution.

5.2 Wine supply chain

In order to better describe how traceability can be assessed in the food industry, an analysis of the wine industry is provided. The wine supply chain follows the scheme provided in the previous chapter of food supply chain. The production phase is performed by grape growers who grow and harvest the grapes. This phase has a central importance because the quality of the wine strongly depends on the quality of the grapes. Wine producers deal with the processing phase where they receive the grapes, they elaborate them, and they blend wine products. This phase can vary a lot depending on the final product, but a general overview might involve receiving the grapes, crushing, stemming, and pressing juice, addition of sulfite, decanting, addition of yeast, fermentation, storage in oak or stainless-steel barrels, filtration, and preparation for bottling[44]. Once the wine is ready it is managed by the packer or often small-medium-size wine companies perform the packaging in-house. After the packaging phase, the logistics takes place, and the wine is shipped to the different distributors or importers. Freight operators take care of the shipment, and they select the best option for sending the wine to the different destinations. Once the product reached the different distributors and eventually retailers it is ready to for consumption by the final consumer.

5.3 Need for traceability in the wine industry

The growing need for traceability is a phenomenon also hitting the wine industry for different reasons. Implementing a fully traceable supply chain in this industry is a big challenge considering the number of players involved and the great number of processes required to produce a bottle of

[44] Garcia A. F., Marchetta G. M., Camargo M., Morel L., (2012), A framework for measuring logistics performance in the wine industry, *International Journal of Production Economics*, 135, 1: 284 – 298.

wine. Nevertheless, it is fundamental to have fully traceable supply chains for different reasons. Consumers are becoming more and more skilled, searching for the best products on the market and learning great amount of information about what they buy. The wine market covers a broad range of qualities and prices, with bottles worth up to 45,000$[45]. Given the prices that wine can reach, it is fundamental for a customer to assess the quality of the product. This trend in consumer behaviour might be also pushed by wine frauds. Scams have always existed in the wine industry, dating back to the Roman Empire. Regulations have been approved along the years, but the problem is still present. It possible to identify two types of wine frauds[46]. The first one is wine adulterations when chemicals, sweeteners, other substances, or lower quality grapes are added to the wine in order to give it a better colour and flavour. Nowadays blending among different kind of grapes are accepted and regulated with precises laws, listing all the possible blending accepted. Counterfeiting is the second wine fraud that consumers can face on the market. At first the fraud consisted in taking wine from an anonymous region and labelling it with a more prestigious provenance. Local governments addressed this issue by introducing boundaries to wine production regions and requirements for wines[47]. After the introduction of these systems protecting the origin of wine, counterfeiting evolved into identity theft of higher quality wine estates. In this way cheap wines are labelled with the name and the description of fine wine producers. This type of fraud requires care for details and packaging but it's becoming more and more common, especially with the rise in online purchases. The existence of such scams makes having a traceable and reliable supply chain a fundamental element for addressing consumers' trust and needs.

[45] Wine prices: https://www.wine-searcher.com/most-expensive-wines
[46] Romano D., Rocchi B., Sadiddin A. (2021), A SAM-Based Analysis of the Economic Impact of Frauds in the Italian Wine Value Chain, *Italian Economic Journal*, 7: 297–321.
[47] Every country has its own appellation system of protected origins: Appellation d'origine controlee (AOC) in France, Denominazione di origine controllata (DOC) in Italy or Denominaciòn d'origen (DO) in Spain

5.4 Case Study: Cantina Placido Volpone

Cantina Placido Volpone is an Italian winemaker based in Puglia - Southern Italy. The winery was born from the shared love among two families for the region and its rich natural heritage. An actor and a farmer decided in 1976 to start growing grapes and they founded Cantina Placido Volpone. The company now offers 9 different labels, from white to red wine and rosé. In 2017 the winemakers decided to embark on a Blockchain-based project with Ernst & Young[48] and the startup EZ LAB[49]. The aim of this project was to enhance the transparency of the company toward its clients and create awareness concerning the territory where they grow their fruits. At the same time the Blockchain supported the protection of Made in Italy agricultural products, assessing the quality of the final product.

Cantina Placido Volpone decided to start using Blockchain-based traceability system on one of his wines: Falanghina white wine.

5.4.1 EY Wine Blockchain

The system developed by the two partners EY and EZ LAB and later adopted by Cantina Placido Volpone requires every player of the supply chain to contribute and record data. The first requirement is that every entity involved in the process has its own encrypted digital signature[50]. This signature allows for identification of the source of information.

The production phase is of great importance because it contains a lot of important data, and the quality of the final product strongly depends on such phase. The farmer growing the grapes has to track the following data: the location, fertilizers, antiparasitic and all the chemicals used to treat the vines. The date and time of the transaction are automatically recorded along with the digital signature of the producer. At the time of harvest the grapes are collected and prepared for transportation to the processing

[48] Ernst & Yong is a multinational professional services network working across consulting, assurance, law, strategy, tax, and transactions

[49] EZ LAB is a stratup providing Blockchain solutions and smart technologies for agri-food companies

[50] EY focus on blockchain: https://www.ey.com/en_gl/tax/how-blockchain-is-moving-from-the-lab-to-the-production-line

plant. The transporter, who may be the same person of the farmer or an external person, has to record the quality and quantity of grapes he is loading for transportation. During the vinification the grapes are transformed as described in section 5.2 and the number of the wine tank are recorded. Once the product is ready the kind of wines obtained are recorded along with the quantities. The wine is then bottled and labelled, and it is ready to be shipped to wholesalers. The date of bottling is recorded as well as the date of harvest. Labelling is a fundamental activity because a QrCode is placed on the label, and it allows the consumer to access all the information concerning the wine[51]. Before reaching the final consumer, bottled wine goes through wholesalers and retailers. Wholesalers have been requested by Cantina Placido Volpone to become an active part of the tracking process and they provided them with the encrypted digital signature. As for the retailers the tracking process is not complete, but QrCodes give information about date, time, and location of the scanning.

Once the client scans the QrCode he reaches a landing page on the Cantina Placido Volpone website where the following information are listed: history and background of the winery, the geographical area, the cultivation, and the vinification process. Table 5.1 provides the data available to the final client for a bottle of Altomare Wine 2017. For every information available on the landing page a button "Verify certification" allows the consumer to check the hash and transaction id.

5.4.2 Impact of the use of Blockchain

Cantina Placido Volpone started using Blockchain in 2017 and year by year they evaluated the impact of the adoption of this system. The goal of increased traceability, trust, and care for environmental issues is met since many consumers identify the winery for these reasons. In terms of sales

[51] Luzzani G., Grandis E., Frey M., Capri E. (2021), Blockchain Technology in Wine Chain for Collecting and Addressing Sustainable Performance: An Exploratory Study, *Sustainability*, 13, 12898.

the Blockchain did not generate a steep increase[52], but this might be due to the heterogeneous market served by the company and the high share of export, mainly towards Eastern Europe. On the other hand, Blockchain helped a lot in preventing counterfeiting which is more and more common especially in the export market. The Blockchain label gained a lot of interest among consumers who discovered Cantina Placido Volpone thanks to this feature. At the same time the number of QrCode scans have increased, again confirming the increasing interest in the technology itself and in the history of the product[53].

6. Typicalp project

In order to further investigate the use of Blockchain technology as a traceability tool, a qualitative interview about the project Typicalp was performed. The interview was organized with the project operations manager Luca Vernetti-Prot and the communications manager Annaclara De Cio. Leading a qualitative interview allowed for a deep comprehension of the steps needed in order to create an efficient traceability system, the processes and all the challenges faced during the implementation. All the information provided in the further sections are the results of the interview, the data provided by the project members and a deep analysis of the paper *Traceability Platform Based on Green Blockchain: An Application Case Study in Dairy Supply Chain*[54] written by project members.

Typicalp[55] is a project aiming to help micro and small enterprises in the dairy industry to gain competitiveness on the European and global markets while improving and innovating their supply chains. The project is

[52] Luzzani G., Grandis E., Frey M., Capri E. (2021), Blockchain Technology in Wine Chain for Collecting and Addressing Sustainable Performance: An Exploratory Study, *Sustainability*, 13, 12898.
[53] Blockchain backed informations on a bottle of wine: https://placidovolpone.it/vini-saggi/altomare/blockchain-altomare-2017/
[54] Varavallo G.; Caragnano G.; Bertone F.; Vernetti-Prot L. and Terzo O. (2022), Traceability Platform Based on Green Blockchain: An Application Case Study in Dairy Supply Chain, Sustainability, (14), 3321
[55] Typicalp project: https://www.progetti.interreg-italiasvizzera.eu/it/b/78/typicalp

funded by the ERDF[56] and it is implemented between Italy and Switzerland, specifically in Aosta Valley region in Italy and in Valais in Switzerland. The name stands for Typicity, Innovation, Competitiveness In Alpine Dairy Products. Typicalp started in December 2018 and its official launch was in July 2019. The main idea is to protect the typicity of dairy products and their processing while enhancing and communicating such value to the final consumer. The innovation of the supply chain is focused on the use of different technologies and Blockchain is a fundamental tool in this project.

The project is organized in different work packages[57] which allow for a better definition of the steps needed to complete the project. They are:

a) Management and coordination involve the definition and monitoring of the objectives, the guarantee of an efficient communication system between the different members of the project and the accounting and reporting of all the costs.
b) Communication is focused on the dissemination of the projects itself and its results. This work package is of great importance regarding the technology because spreading the product and process innovation in the dairy industry allows for the recognition by local entities and for the creation of new partnerships.
c) Improvement of quality and processes is the heart of the project along with the following work package. In this section, after an analysis of the processes and the regulatory framework, the innovation of the supply chain is performed. Even if the two regions involved in the project are different, they share the same problems concerning animal welfare, sanitary regulations, logistic efficiency. Blockchain, along with other technologies, is a key instrument to solve some of these issues.
d) Improvement of competitiveness is the work package where the two regions are given technical support to improve their processes and

[56] ERDF stands for European Regional Development Fund whose aim is to strengthen economic, social, and territorial cohesion in the European Union
[57] Work projects are sub-projects, they are a building block of the work breakdown structure. All the work projects combined form the completed project.

the quality of their products. This stage is where the traceability process is implemented using technology. The aim of this work package is to trace and track all the activities in the dairy supply chain, from the milk producer to the final consumer. Given that innovation is one of the main drivers of the whole project, an efficient traceability system can be achieved by using Blockchain technology. This system will enhance trust and create a bond between the consumer and the different producers.

e) Networking and Marketing is the last work package of the project. The idea is to create a solid network between local enterprises, research hubs, public entities, and associations. This cooperation should occur also between Aosta Valley and Valais to better exploit the results and the innovations of the project and create new partnerships. Also, after the innovations of the previous blocks, the idea is to continue training people and enterprises. In this section, communication becomes central again because, to attract new partners and expand the project, the projects itself, its results, and its players need to be properly communicated to all the different stakeholders.

6.1 Typicalp in Aosta Valley

Italy is the head of the project, and the main player is Institut Agricole Régional[58]. This institution is based in Aosta, Aosta valley region, and it collaborates with other local players and the main Swiss player HES-SO, University of applied sciences.

The dairy market is broad in Aosta Valley[59] offering different products ranging from fresh and seasoned cheese to milk, yogurt, ice cream, cream, and butter. To perform experimentation and analysis only one product of the dairy industry was chosen: Fontina. Fontina is the name of the most well-known cheese produced in Aosta Valley since the 13th century. It is

[58] Institut Agricole Regional is a school, research center, and scientific disseminator based in Aosta – Italy. The areas of interest are wine production, the dairy industry, and fruit growing.

[59] Dairy livestock activities represent 28% of agricultural GDP of the region

made from whole cow milk, and it has a semi-soft and elastic texture with a medium-sharp flavor, making it a product suitable for different tasting purposes. Other than the distinctive and easily detectable shape and flavor, the great value of Fontina resides in its production process which will be explained in the next section.

6.2 Dairy supply chain of Fontina

The supply chain of Fontina consists of different phases which are all performed within the Aosta Valley borders. In the past years, some attempts were made, and the local milk was processed and seasoned outside the region, but the result was different. The dairy supply chain of Fontina has five stages[60]:

a) Milk production is the first step where the farmers collect milk, the primary ingredient. In this phase several requirements on the quality and procedures have to be met milk must be raw, whole, and coming from a single milking. The raw milk must then be processed within two hours after milking. The milk is delivered by every farmer to the transformer.
b) Processing starts when all the collected milk is delivered to diaries. Milk must not exceed the temperature of 36° to be processed. The milk is processed in cheese vats for a period of 40 minutes. Once this phase is completed, a semi-finished cheese is a result.
c) Seasoning is the longest phase in the supply chain, and it starts by moving the semi-finished product to a different location. Proper seasoning of Fontina occurs in warehouses where the temperature is between 9° and 12° and humidity is at least 90%. There, the seasoning process lasts for at least three months.
d) Packaging is performed in the same location as the seasoning. The materials used for packaging are usually a protective atmosphere,

[60] Production Regulations for Fontina available online: https://www.fontina-dop.it/wp-content/uploads/2021/09/Disciplinare-Fontina-mipaaf.pdf

propylene film, and food paper. Fontina wheels that are packed weigh from 7.5 to 12 kg and have a diameter of 35-45 cm.

e) Sales are the last step of the chain, and it starts with the portioning in 1-2 kg slices and the distribution on the market. Once the product reaches the final retailer, the shelf life for the entire Fontina cheese is around 150 days while for the portioned cheese 63 days.

Fontina cheese is protected with PDO[61] mark due to its strong link to the region, making it a 100% local product. All the production requirements are defined by the Fontina Consortium, the institution protecting and sharing the value of this product.

6.3 Typicalp traceability system for Fontina

Fontina cheese was chosen to test the innovations on the traceability system of the supply chain because it has a great number of requirements, other than those requested by law, and it is well-known all over the world. The technology for traceability was developed by Links Foundation[62], one of the partners of the project, who dealt with the engineering aspects and developed the Blockchain-based traceability system. The Blockchain used for the project was Algorand Blockchain that is highly scalable and environmentally sustainable. A traceability system already existed due to the health and food safety requirements of the industry. The information collected were the quantity of milk delivered by each farmer, the date and time, the temperature and the farmer's identification code. The technology developed in the framework of Typicalp project integrates the existing system adding data on all the five phases of the supply chain. The collected information is made reliable and immutable using Blockchain. To integrate the existing traceability system, focus groups were organized and interviews to the different players of the supply chain were carried out. After the research phase the traceability platform was organized on a web

[61] PDO stands for Protected Designation of Origin, and it is an EU geographical indication for products having a strong link to the place in which they are made

[62] Links Foundation has been working for 20 years in applied research, innovation, and technology transfer

application usable by all players of the supply chain. The platform has an architecture based on three elements:

a) Back-end framework is the software part of the system, and it contains all the functions for entering, recording, and reading data.
b) Relational Database Management System (RDBMS) contains the mandatory data to be recorded for traceability purposes. Also, necessary table and fields are defined in this part. The relational database management system used is MySQL.
c) Distributed Ledger Technology (DLT) is the element on what Blockchain is based and it allows for the immutability of the data.

Table 6.1 provides a scheme of the architecture of the traceability system above described.

Every operator has to record information based on the data model designed in the RDMS and DLT. The operator's name and ID and the time and date of the transaction are automatically recorded by the system. Once every phase is performed the product is identified with the name of the phase and *id*[63].

The farmer producing milk normally delivers the milk to the transporter with the previous system information. The transporter is the first subject actively using the traceability platform. After collecting the milk from the farm, he has to register the quantity of milk collected, the kind of farm (mountain pasture or valley) and the date and time of the collecting of raw milk. As a last step he uploads a picture with the receipt of the quantity supplied by each farmer in order to double check the information. The second operator dealing with the traceability system is the dairy worker who has to select the *milk_production_id* to be processed based on what the plant received. Once the processing is done the number of semi-finished products and the kind is uploaded. In this case the only product kind is Fontina cheese, but the data model is designed to be applied in future to

[63] Varavallo G.; Caragnano G.; Bertone F.; Vernetti-Prot L., Terzo O. (2022), Traceability Platform Based on Green Blockchain: An Application Case Study in Dairy Supply Chain, *Sustainability*, 14, 3321.

other products of the dairy industry and also to other industries. Once the processing phase is completed, the product moves to the seasoning warehouse. The seasoning operator selects the *processing_id* containing the number of semi-finished products that should mature. Informations about the beginning and the end of the seasoning period are registered along with the number of wheels that receive the Fontina Consortium approval. The packaging operator selects the *seasoning_id* and uploads the date of packing and the subsequent shelf life. Once the transaction is confirmed the operator obtains the QrCode, containing all the information recorded. At this point the traceability system stores all the data in the Blockchain. Once the Fontina cheese is delivered to the shop the sales operator places it on the shelves for purchase. The date and time of QrCode scanning help to understand where and when the product is purchased.

To test the whole system, two medium-sized dairies were selected. At the moment the trial is almost completed, and the results are good. The dairy workers were concerned about wasting too much time on the tracking activities, but the system is user-friendly and requires only few minutes per operator. At the same time the data collected are satisfying and detailed.

6.4 Future developments

Typicalp project is supposed to terminate at the end of 2022. The idea is to renew the project or to create a different and new project as an evolution of the first one. The aim is to continue the process of innovation of the supply chain with new technologies or new applications of the current assets. Focusing on Blockchain technology, the hope is to broaden the traceability system also to the other products of the dairy industry. If the testing phase is concluded with positive results, the system will be extended to all the Fontina producers in Aosta Valley. After one more year of trial, the technology could be ready to cover the whole dairy industry in Aosta Valley. One easily reachable goal is to add in the traceability system also pictures and videos, showing the cows and the different processing phases. The main hope of the project members is to create an efficient system which

can be used in different industries. For this reason, the back end was designed in order to be highly and easily customizable, in order to meet the needs of very different supply chains.

7. Conclusions

Traceability, as already mentioned, is a central topic for every company in the fashion and food industry. Supply chain schemes have been integrated with many technologies but some issues such as trust, security of data, and transparency were almost unaddressed until recently. Even if most companies have digitalized their supply chain and logistics, information about suppliers, processes, and certifications claimed by firms often lacked references and credibility and led consumers and/or stakeholders to doubt or not trust companies. To achieve an efficient traceability system, technology is a fundamental requirement. Blockchain, along with other technologies such as IoT or artificial intelligence, can help companies building digitalized, reliable, and transparent supply chains. Putting aside all the current fuss around the Blockchain technology and its new applications such as NFTs [64], it is important to focus on its characteristics. Blockchain allows for the storage of any kind of data in a secure and immutable way. These features make it a great tool for many different purposes and uses. Nevertheless, Blockchain after fifteen years from its introduction is still in an early stage of adoption, with few companies actively integrating it in their corporate processes. Supply chain management is an area in which the technology can become a real game-changer due to the involvement of all the stakeholders, and a complex process that demands the availability of transparent, trustable, and real-time data. However, to achieve a widespread usage, some critical challenges need to be addressed, such as the lack of a standardized regulatory framework, high energy demand, and high cost.

[64] As already mentioned, Blockchain has a broad use in cryptocurrencies market. Recently Blockchain has been used for NFTs – Non-Fungible Tokes which are digital assets with unique identification code, and they can be traded.

Hence, based on the literature review and the qualitative survey, it can be concluded that blockchain technology can provide significant benefits to companies. Figure 7.1 provides a scheme of how a company can organize a Blockchain based supply chain to achieve traceability and transparency. The creation of a shared and distributed ledger between all the players involved in the supply chain can impact the way a company works from an operational standpoint and from a reputation standpoint. The first immediate consequence of the adoption of Blockchain technology is towards increased efficiency and flexibility in supply chains processes. It allows for the establishment of a well-functioning system in which everyone has the same amount of information available at the same time, which is a great achievement especially in fragmented and global supply chains where communication inefficiencies are a common issue. At the same time companies gain trust, transparency, and traceability, re-designing the relationship with their customers. Brand value and brand engagement increase, especially to the eyes of more demanding customers. These factors allow companies to shift towards more sustainable practices, to establish data-driven systems and new business models, both in the fashion and the agri-food industry.

Tables

Table 1.1 - Sustainable Development Goals

No.	Goal	Description
1	No poverty	End poverty in all its forms globally
2	Zero hunger	End hunger, reach food security and promote sustainable
3	Good health and well-being	Healthy lives and promootion well-being for all at all ages
4	Quality education	Inclusive quality education and promotion of lifelong learning opportunities
5	Gender Equality	Achievement of gender equality and empowerement of girls and women
6	Clean water and sanitation	Availability and sanitation of water for all
7	Affordable and clean energy	Affordable, reliable, sustainable and moden energy for all
8	Decent work and economic growth	Inclusive and sustainable economic growth and decent work for all
9	Industry, innovation and infrastrcture	Resilient infrastructure and inclusive and sustainable inidustrialization
10	Reduced inrqualities	Inequality reduction among and within countries
11	Sustainable cities and communities	Inclusive, safe, resilinet and sustainable cities
12	Responsible consumption and production	Sustainable consumption and production
13	Climate action	Fight cimate change and its impacts
14	Life below water	Sustainable use of oceans, seas and marine resources
15	Life on land	Protection and sustainable use of ecosystem, halt biodiversity loss and combat desertification
16	Peace, justice and strong institutions	Peacuful and inclusive societis, access to justice for all
17	Partnership for the goals	Strenghten the means of implementation for each goal

Table 4.1 - The Provenance Framework

Category	Tag	Description
Climate	Carbon Measured	Measurement of greenhouse gas emissions was performed
	CarbonNeutral Company	Emissions are reduced to zero
	Carbon Offsetting	Support of external projects for compensating internal emissions
	Climate Neutral	Reduction or offsetting of emissions
	Net Zero	Emissions are reduced to zero or offsetting projects
	Reduced Carbon Footprint	Reduction in emissions through mitigation practices
	Renewable energy	80% (at least) of energy used comes from renewable sources
Waste	Compostable Parts	Parts of the packaging are capable to decompose naturally
	Cradle to Cradle	Product standard certification based on environmental and social performance
	Fully Compostable	Packaging is capable of decomposing naturally
	Fully Recycled Packaging	Packaging is made of waste materials (recovered, reprocessed, converted)
	Partly Recycled Packaging	Parts of the packaging are made of waste materials (recovered, reprocessed, converted)
	Partly Recyclable Packaging	Part of the packaging can be broken down into raw materials and repurposed
	Plastic-free	Product or packaging or both are plastic-free
	Reduced Waste Footprint	Measurement and reduction of waste production
	Reducing Food Waste	One or more practices to reduce the amount of food waste
	Reducing Material Waste	One or more practices to reduce the amount of waste
	Reusable Packaging	Packaging designed to be reused for the same use
	Upcycled	Parts of the product were converted from materials that would have been discarded
	Widely Recyclable Packagin	Packaging can be broken down into raw materials
Workers	Artisan producers	Promotion of traditional craft and capabilites of
	B Corporation	Certification for social performance, including
	Cooperative Organization	Business run jointly by members who share the profits and the benefits
	Fair For Life	Fair trade approach and fair remunerations for supply chain players
	Fairtrade	Social and economic standards for businesses and
	Improving Purchasing Practices	Practices to drive the improvement of working conditions along the supply chain
	Living Wage	Business paying a living wage to all its employees
	Supports Trade Union	Workers have the right to unionise and bargain collectively for their rights

Category	Tag	Description
Nature	Alliance for Water Stewardship	Certification for a correct management of water
	Coral Reef Safe	Product does not contain oxybenzone, octinoxate or nano-particles
	Cosmos Standard Organic	Certification for genuine organic products or natural cosmetics
	Demeter Biodynamic	Farm meets the organic standard based on holistic farming principles
	FairWild	Plant collectors demonstrating commitment to environmentally wild collections
	Free Range	Animals can roam freely outdoors for a significant period (specified by national laws)
	FSC	Certification for products made with materials from well-managed forests
	Improving Farming	Practices towards a more regenerative and sustainable farming system
	Leaf Marque	Certification identifying a farm approach based on Integrated Farm Management
	Leaping Bunny Cruelty-Free	Commitment to help ending animal testing
	MSC	Certification for meeting the Fishery Standards for sustainability
	Natrue Natural	Label to help consumerd identify natural and organic cosmetics
	Organic Cotton (GOTS)	Requirements throughout the supply chain in textile and apparel manufacturing
	Organic Ingredients	Product containing organic ingredients but non
	PETA Cruelty-Free	Certification for cruelty-free and vegan products
	Protecting Water Quality	Practices to reduce water pollution as a result of production
	Rainforest Alliance	Certification for meeting environmental and social standars (farm, forest, tourism)
	Red Tractor	Certification for products that meet huan consumption safety standards (UK)
	Reduced Water Footprint	Measurement and reduction of total water consumption
	Reduced Water Use	Measurement and reduction of water consumption used for producion
	RSPCA Assured	Certification for meeting specific standards in farrming and in production
	Soil Association Organic	Certification for protection of anumal welafare and human health
	Vegan	Product does not contain animal products or derivates
	Vegetarian	Product does not contain ingredients coming from animal slaughter

Category	Tag	Description
Communities	1% for the Planet	Global movement supporting environmental solution for businesses and individuals
	Black Founded Business	Majority of founders (51%) identifies as black people
	Black Owned Business	Majority of shares (51%) detained by black people
	Clinically Tested	Product tested on humans on a clinical setting
	Donates to Charity	Support to one or more non-profits
	EWG VERIFIED	Standards for eliminating toxic chemicals and have a trasparent ingredient list
	Family Owned Business	Majority of shares (51%) detained by people who identify as a family
	Female Owned Business	Majority of shares (51%) detained by women
	Free From Artificial Flavours	Product does not contain synthetically produced flavours
	Free From Synthetic Preservatives	Product does not contain synthetically produced preservatives
	Independently Owned	Majority of shares (51%) detained by the same person or group
	No Added Sugar	Product does not contain foods used solely for sweetening properties
	Person of Colour Founded Business	Majority of founders (51%) identifies as people of colour
	Person of Colour Owned Business	Majority of shares (51%) detained by people of colour
	Scientifically Tested	Product tested to ensure safety and performance
	Supporting Education	Support of education-related projects in the supply chain
	Supporting Health	Support of health-related projects in the supply chain
	The Butterfly Mark	Assessment of material risks for different industries (climate, waste, biodiversity)

Table 5.1 - Altomare wine 2017 Blockchain-backed infromations

Geographical area	
Land	Land located in Orta Nova municipality with 4700 grapevines
Cadastral Management	1,35 hectares registered with number 56 - 43
Cultivation timeline	
Date	**Intervention**
15/12/16 to 10/01/17	Winter pruning
14/12/16 to 22/01/17	Removal of the sarments
22/02/17 to 26/02/2017	Tying of the vines
01/03/17	Fertilization
20/03/17 to 23/03/17	Phoerormones diffusion
01/04/17	Mechanical weeding
10/04/17 to 18/04/17	Spring pruning
May and July 2017	Treatments against bacteria
25/06/17	Mechanical topping
24/07/17	Veraison
23/08/17	Pre-harvest ripening
From 10/09/17	Analysis
21/09/17 to 23/09/17	Grape harvest
Vinification timeline	
Date	**Process**
21/09/17 to 23/09/17	Grapes enter the vinery
21/09/17 to 23/09/17	Analysis
21/09/17 to 23/09/17	Destemming and crushing
22/09/17 to 24/09/2017	Racking
24/09/17	Introduction of selected yeasts
24/09/17 to 06/10/17	Fermentation
06/10/17	Barrique
07/01/18	Racking
From 07/01/18	Refinement in steel
From 03/03/18	Sedimentation of the less
From 14/04/18	Clarification
From 26/04/2018	First filtration
From 03/05/18	Tartaric stabilization
01/06/18 to 19/07/18	Last filtrations and bottling
From 19/08/18	Refinement

Figures

Figure 3.1 – Fucntioning of Blockchain Technology

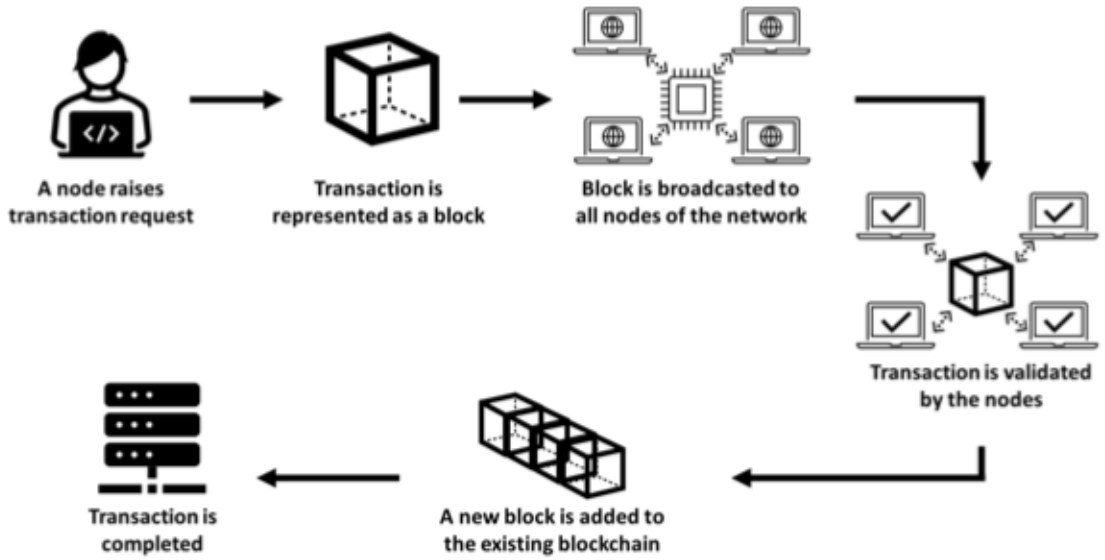


Figure 6.1- Architecture of traceability system developed by Typicalp

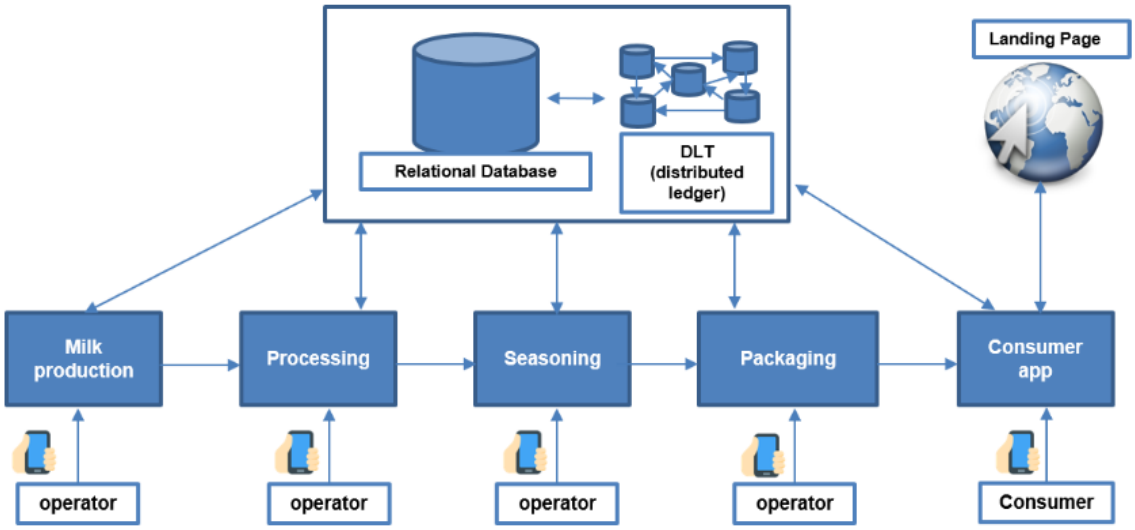
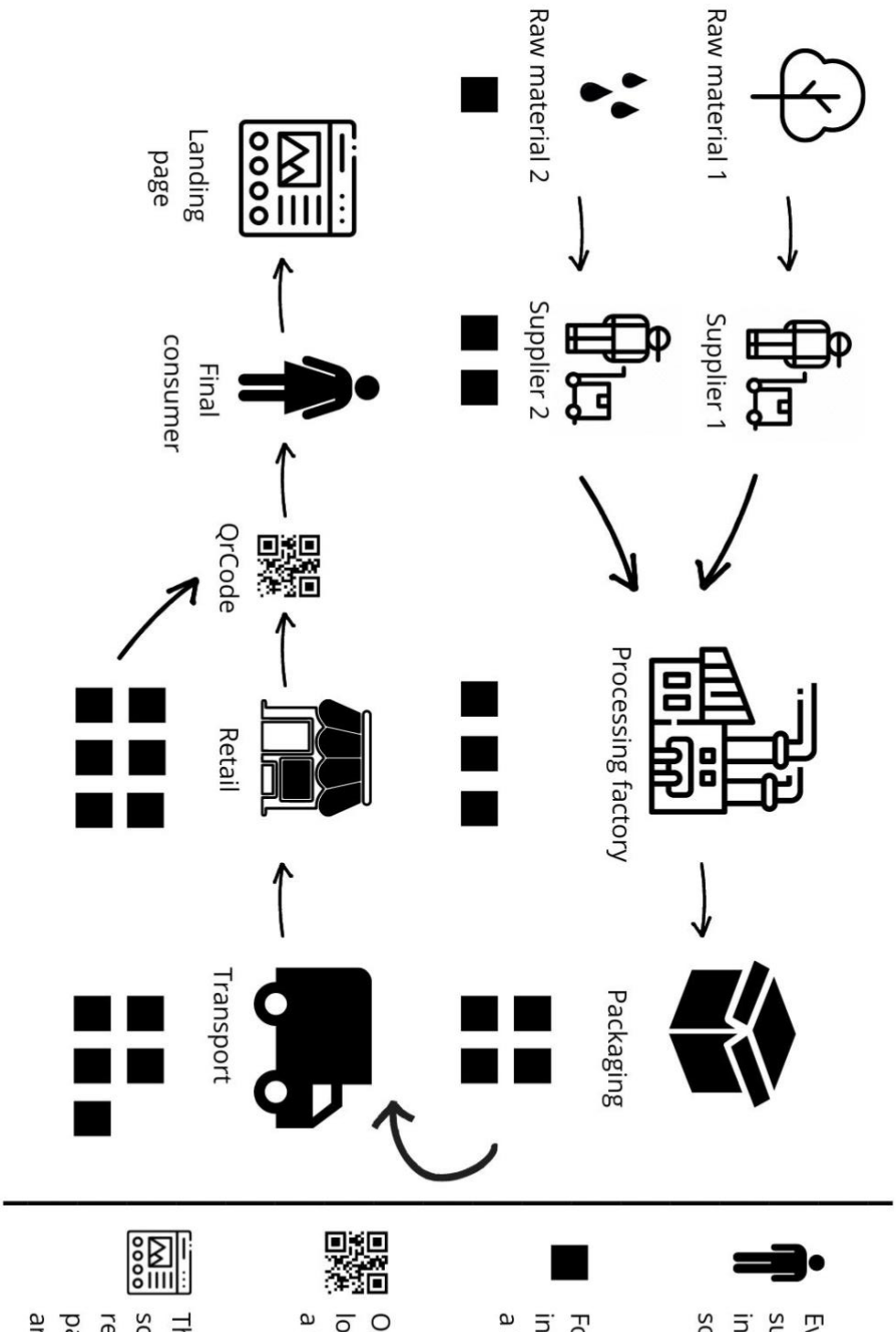


Figure 7.1 – Blockchain based supply chain system



Reference bibliography

Agrawal T.K., Kumar V., Pal R., WangL., Chen Y. (2021), Blockchain-based framework for supply chain traceability: A case example of textile and clothing industry, *Computers & Industrial Engineering*, 154: 107130.

Ahumada O. and Villalobos J.R. (2009), Application of planning models in the agri-food supply chain: A review, *European Journal of Operational Research*, 96, 1: 1 – 20.

Awaysheh A., Klassen R.D. (2010), The Impact of Supply Chain Structure on the Use of Supplier Socially Responsible Practices, *International Journal of Operations and Production Management,* 30, 2: 1246–1268.

Ball S., Sharples L. and Eastham J. (2007), *Food supply chain management – Issues for the hospitality and retail sector*, Butterworth-Heineman

Bezovski, Zlatko, Jovanov, Tamara, Temjanovski, Riste (2021) The Impact and the Potential Disruption of the Blockchain Technology on Marketing, *Journal of Economics*, 6, 1: 13-23.

Bischoff O. and Seuring S. (2021), Opportunities and limitations of public blockchain-based supply chain traceability, *Modern Supply Chain Research and Applications*, 3, 3: 226-243.

Brous P., Janssen M., Herder P. (2020), The dual effects of the Internet of Things (IoT): A systematic review of the benefits and risks of IoT adoption by organizations, *International Journal of Information Management*, 51.

Bullón Pérez J.J., Queiruga-Dios A., Gayoso Martínez V., Martín del Rey Á. (2020), Traceability of Ready-to-Wear Clothing through Blockchain Technology, *Sustainability,* 12, 18:7491.

Chandan A., Cheela V.R.S. and Dube B. (2021), Life Cycle Analysis to Estimate Environmental Impact of the Food Industry, *Emerging Treatment Technologies for Waste Management*, 154–156.
Christopher M. (2013), *Logistics and supply chain management*, 4th edition, Edinburgh: Pearson.

Danese, P., Mocellin R. and Romano P. (2021), Designing blockchain systems to prevent counterfeiting in wine supply chains: A multiple-case study, *Int. J. Oper. Prod. Manag*, 41:1–33.

De Boissieu E., Kondrateva G., Baudier P. and Ammi, C. (2021), The use of blockchain in the luxury industry: supply chains and the traceability of goods, *Journal of Enterprise Information Management*, 34, 5: 1318-1338.

Feng T. (2016), *An agri-food supply chain traceability system for China based on RFID & blockchain technology*, 13th International Conference on Service Systems and Service Management (ICSSSM*)*, 1-6.

Fu B., Liu X. and Shu Z. (2018), Blockchain Enhanced Emission Trading

Framework in Fashion Apparel Manufacturing Industry, *Sustainability journal*, 10, 4, 1105.
Garcia A. F., Marchetta G. M., Camargo M., Morel L., (2012), A framework for measuring logistics performance in the wine industry, *International Journal of Production Economics*, 135(1): 284 – 298
Garcia-Torres S., Rey-Garcia M., Sáenz J., Seuring, S. (2022), Traceability and transparency for sustainable fashion-apparel supply chains, *Journal of Fashion Marketing and Management*, 26(2): 344-364.
Heim H., Hopper C. (2022), Dress code: the digital transformation of the circular fashion supply chain, *International Journal of Fashion Design*, Technology and Education, 15, 2: 233-244
Huber N., Michael K., McCathie L. (2007), *Barriers to RFID Adoption in the Supply Chain*, 1st Annual RFID Conference Eurasia, 1-6.
Huynh P.H. (2022), Enabling circular business models in the fashion industry: the role of digital innovation, *International Journal of Productivity and Performance Management*, 71, 3: 870-895.
Kamilaris A., Fonts A., Prenafeta-Boldủ F.X. (2019), The rise of blockchain technology in agriculture and food supply chains, Trends in Food Science & Technology, 91: 640-652
Katz J., Lindell Y. (2021), *Introduction to Modern Cryptography*, Boca Raton: CRC Press.
Kirch M., Poenicke O., Richter K. (2017) RFID in Logistics and Production – Applications, Research and Visions for Smart Logistics Zones, *Procedia Engineering*, 178: 526-533.
Klepp I.G., Laitala K., Wiedemann S. (2020), Clothing Lifespans: What Should Be Measured and How, *Sustainability*, 12, 6219.
Kloster D. (2018), *Digital Identity: On the Threshold of a Digital Identity Revolution*. Working Paper, World Economic Forum, Geneva.
Justin S., Naveen U., Madhusudanan P. (2020), Supply chain transparency through blockchain-based traceability: An overview with demonstration, *Computers & Industrial Engineering*, 150.
LeMay S., Helms M.M., Kimball B., McMahon D. (2017), Supply chain management: the elusive concept and definition*, The International Journal of Logistics Management*, 28, 4: 1425-1453.
Luzzani G., Grandis E., Frey M., Capri E. (2021), Blockchain Technology in Wine Chain for Collecting and Addressing Sustainable Performance: An Exploratory Study, *Sustainability*, 13,12898.
Luzzani, G.; Lamastra, L.; Valentino, F.; Capri, E. (2021), Development and implementation of a qualitative framework for the sustainable management of wine companies, *Sci. Total Environ*, 759, 143462.
Martinez-Julia P., Gomez-Skarmeta A.F., Girao J., Sarma A. (2011), Protecting digital identities in future networks, Future Network & Mobile Summit, 1-8.
Nagurney A., Yu M. (2011), Fashion Supply Chain Management Through Cost and Time Minimization from a Network Perspective, *Fashion Supply Chain Management: Industry and Business Analysis*, 1 – 20.
Olsen P., Borit M. (2018), The components of a food traceability system,

Trends in Food Science & Technology, 44, 77: 143-149.
Renata O., Garcia C., Góes Pinto P. (2020), Accessibility to Food Retailers: The Case of Belo Horizonte, Brazil, *Sustainability* 12(7), 2654
Rinaldi F.R. and Testa S. (2013), *L'impresa moda responsabile: integrare etica ed estetica nella filiera,* 1st edition, Milan: Egea.
Rinaldi F. R. (2020), *Fashion Industry 2030: Reshaping the Future Through Sustainability and Responsible Innovation*, Milan: Egea.
Rinaldi F.R., Di Bernardino C., Cram-Martos V., Pisani M.T. (2022), Traceability and transparency: enhancing sustainability and circularity in garment and footwear, *Sustainability: Science, Practice and Policy*, 18, 1: 132-141.
Romano D., Rocchi B., Sadiddin A. (2021), A SAM-Based Analysis of the Economic Impact of Frauds in the Italian Wine Value Chain, *Italian Economic Journal*, 7: 297–321.
Roy V. (2021), Contrasting supply chain traceability and supply chain visibility: are they interchangeable?, *The International Journal of Logistics Management*, 32, 3: 942-972.
Sarpong S. (2014), *Traceability and supply chain complexity: confronting the issues and concerns*, European Business Review, 26(3): 271-284.
Simatupang T., Sridharan R. (2003), The Collaborative Supply Chain: A Scheme for Information Sharing and Incentive Alignment, *The international journal of logistics management*, 46, 3: 102-125.
Shahid A., Almogren A., Javaid N., Al-Zahrani F.A., Zuair M., Alam M. (2020), Blockchain-Based Agri-Food Supply Chain: A Complete Solution, *IEEE Access*, 8: 69230-69243,
Skilton P.F., Robinson J.L. (2009), Traceability and normal accident theory: How does supply network complexity influence the traceability of adverse events? *Journal of Supply Chain Management*, 45, 6: 40–53.
Sumarilah E., Li T., Wang B., Fauziyah F., Indriya I. (2022), Blockchain-Empowered halal fashion traceability system in Indonesia, *Int. J. of Information Systems and Supply Chain Management*, 15, 2.
Timmer M.P., Los B., Stehrer R. et al. (2021), Supply Chain Fragmentation and the Global Trade Elasticity: A New Accounting Framework, *IMF Econ Rev,* 69: 656–680.
Varavallo G.; Caragnano G.; Bertone F.; Vernetti-Prot L., Terzo O. (2022), *Traceability Platform Based on Green Blockchain: An Application Case Study in Dairy Supply Chain*, Sustainability, 14, 3321.
Yim J., Yoo H. Kwak J. and Kim S. (2018), Blockchain and consensus algorithm, *Electron. Telecommun. Trends*, 33: 45–56.
Yan Xu, Xiangxin Li, Xiangquan Zeng, Jiankang Cao & Weibo Jiang (2022), Application of blockchain technology in food safety control：current trends and future prospects, *Critical Reviews in Food Science and Nutrition*, 62:10, 2800-2819.

Blockchain:
https://www.ibm.com/topics/what-is-blockchain
Cotton production:
http://www.schededigeografia.net/geografia_economica/cotone
Evolution of RFID: https://www.abr.com/evolution-of-rfid/
FAO food price index:
https://www.fao.org/worldfoodsituation/foodpricesindex/en/
EY focus on blockchain:
https://www.ey.com/en_gl/tax/how-blockchain-is-moving-from-the-lab-to-the-production-line
Food safety:
https://www.who.int/news-room/fact-sheets/detail/food-safety
Food traceability guidance, FAO (2017):
https://www.fao.org/3/i7665e/i7665e.pdf
Martine Jarlgaard:
https://martinejarlgaard.com
Martine Jargaalrd:
https://www.forbes.com/sites/rachelarthur/2017/05/10/garment-blockchain-fashion-transparency/?sh=70ba205f74f3
Martine Jarlgaard and Provenance technology:
https://www.forbes.com/sites/oliviapinnock/2018/07/25/meet-the-first-fashion-designer-to-adopt-provenances-blockchain-technology/?sh=612484fa7ad6
Provenance framework:
https://www.provenance.org/framework
Provenance results:
https://www.provenance.org/case-studies/cult-beauty
Reshoring supply chains:
https://www2.deloitte.com/us/en/insights/industry/public-sector/government-trends/2022/reshoring-global-supply-chains.html
SDG tracker:
https://sdg-tracker.org/
Sustainable Development Goals:
https://www.un.org/sustainabledevelopment/sustainable-development-goals
Traceability:
http://www.businessdictionary.com/definition/traceability.html
Typicalp project: https://www.progetti.interreg-italiasvizzera.eu/it/b/78/typicalp
United Nations Economic Commission for Europe (2017), Transparency in textile value chains in relation to the environmental, social, and human health impacts of parts, components and production processes, Geneva: UNECE.
UNECE (2017). Implementing UN/CEFACT e-Business standards in Agricultural Trade. Draft Background Research Paper. United Nations.
Wine prices: https://www.wine-searcher.com/most-expensive-wines