UCLouvain

LOUVAIN
School of Management

Louvain School of Management

From farm to fork: how blockchain can enhance traceability in the soy supply chain

Application within the food industry

Author : BATAILLE DE LONGPREY Margot
Supervisor(s) : PAQUE Bernard
Academic year 2020-2021

Acknowledgements

The realization of the intensive research, deep analysis, and thorough writing of this thesis would not have been possible without the support and help of several persons.

First of all, I would like to express my sincerest gratitude to my supervisor, Bernard Paque, Professor at the Louvain School of Management for his prompt responses, precious advice and excellent guidance throughout the entire redaction of this thesis .

Secondly, I would like to thank all participants who responded positively to my request and brought insightful perspective into this research:

- *Evert Raymakers from RTRS*
- *Sylvain Quiédeville from FiBL*
- *Rogan Fichot from Carrefour*
- *Arthur Duquesne from Nestlé*
- *Emese Van Maanen from ProTerra*
- *Estefania Frontero from WeAreMucho*
- *Dogan Basoglu from Alpro*

Finally, I would like to thank my family, especially my sister, Emilie Bataille for her support, outsider view, and suggestions for improvement.

Table Of Contents

List of Figures

List of Tables

List of Appendices

Glossary

A	
B	
C	
CAR	Rural Environmental Registry
CPU	Central Processing Unit
D	
E	
EA	Ethereum Address
EVM	Ethereum Virtual Machine
EU	European Union

EU28	Belgium (BE), Denmark (DK), France (FR), Germany (DE), Greece (EL), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Portugal (PT), Spain (ES) and United Kingdom (UK), + Austria (AT), Finland (FI) and Sweden (SE) Cyprus (CY), Czechia (CZ), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Malta (MT), Poland (PL), Slovakia (SK) and Slovenia (SI) Bulgaria (BG) and Romania (RO) Croatia (HR)
F	
FiBL	Research Institute of Organic Agriculture
FMCG	Fast Moving Consumer Goods
FQC	Filière Qualité Carrefour
G	
GMO	Genetically modified organism
GHG	Greenhouse gas
H	
I	
IoT	Internet of Things
J	
K	
L	
M	
MQTT	Message Queue Telemetry Transport
N	
Non GMO	Non genetically modified organism
O	
P	
P2P	Peer to peer
Q	
R	
RTLS	Real Time Location Systems
RTRS	Round Table on Responsible Soy
S	
SDGs	Sustainable Development Goals
SDR19	Sustainable Development Report 2019
SCM	Supply Chain Management
T	
U	
V	
W	
WSN	Wireless sensor Network
X	
Y	
Z	

Executive Summary

Purpose

This research thesis aims at analysing the potential implementation of blockchain within the soy value chain. It first outlines the need for more traceability in the soy value chain. Then it tackles how the implementation of blockchain could improve traceability. In addition, a concrete application is given by using Ethereum blockchain. Lastly, the qualitative research and analysis allows to compare different perspective.

Originality/Value

This thesis contributes to the scientific literature by providing an overview of the current situation within the soy value chain and more precisely applicable to the food industry. Besides, it explores the potential of blockchain to increase traceability in the soy value chain. Lastly, with the qualitative research and analysis carried out, a managerial conclusion, and recommendations was formulated.

Methodology / Approach

An intensive literature review in different academic journals has been conducted from January to May 2021. The objective was to collect, organize and synthetise existing knowledge relating to the soy industry and blockchain. Furthermore, a qualitative research was done with different stakeholders in the soy industry.

Findings

This thesis described the opportunities and challenges of the implementation of blockchain in the soy industry. The literature review undertaken on the topic has shown that blockchain has been acknowledged as a promising technology regarding food traceability but presents some challenges regarding the specific application in the soy industry.

Recommendations for future research

This thesis focused only on the soy used for food products, as this represents only a small part of the soy industry, investigating other end purposes of soy could be an alternative path to explore.

Introduction

Chapter I. Research Context and Objectives

In 2015, global leaders came together to adopt a common vision for a safer, healthier and more prosperous world by 2030. With this agenda, 17 Sustainable Development Goals (SDGs) and a 169 underlying targets were designed requiring deep transformation in developed and developing countries. Those 17 SDG were designed around 5 main pillars, known as the 5P's, namely, People, Planet, Prosperity, Peace and Partnerships.

The Sustainable Development Report of 2019 (SDR2019) proves evidence that no country has achieved or is on the good track to achieve the SDGs. Statistics on greenhouse gas emissions or loss of fauna and flora are moving in the wrong direction (Czaplicki et al., 2019). The global agricultural industry in its current state, as well as many other industries all have a negative impact on today's SDGs. The agricultural practice has negative externalities in many environmental areas such as water waste, GHG emissions, excessive nutrient outflows, chemical pollution, deforestation but also in many social practices such as child labor or unfair remuneration. It causes negative issues all along its activities: upstream during the production processes, but also downstream during transportation. Faced with the lack of pro-activity of nations towards changes in the industry, non-profit organizations started to ring some alarm bells. Consumers are becoming increasingly aware of the globalized production and distribution of agriculture especially regarding safety and quality. As demand for key agricultural commodities such as soybeans is expected to double by 2030 (Guerrero et al, 2021), this thesis will focus more specifically on the soy production.

The first part of this thesis aims at detailing the *need for traceability in the soy supply chain*, describing where *traceability systems currently stand today*, and *how it can be improved by leveraging the blockchain technology.* Besides, an application of blockchain in the soy supply chain is proposed.

The second part of this thesis will dive into a qualitative research and analysis by discussing this topic with different stakeholders in the soy supply chain: soy certificates, retailers, food companies but also experts on the subject.

Chapter II. Motivations

Numerous motivations drove the author to write this thesis for an increased traceability in the soy supply chain. Over the last decade, food companies have been on many front pages and headlines because of food scandals or contaminations. With the increasing trends towards a vegetarian diet, the intake of nutrients from plant sources, and especially from soy products surged mainly because of its protein content. A great variety of soy-based products becomes more and more available in grocery stores, yet, the origin and quality remains unproved.

The agricultural process of soy has a major impact on the SDGs. It is therefore key to review and challenge its current value chain at each particular step. The soy used directly for food products will be the main focus of this thesis. With increased consumer awareness and continuous innovation, upcoming technologies in this sector play a strategic role in determining tomorrow's soy supply chain. By leveraging blockchain, this thesis will illustrate how the current supply chain can be improved.

This thesis provides a twofold managerial and scientific contribution to the existing literature:

- First, it provides a clear and synthetic overview of the current soy supply chain by highlighting the need for traceability. In addition, it develops an overview of current traceability practices and technologies in the soybean supply chain.
- Secondly, it analyses and explores an innovative solution to enhance traceability by leveraging one of the most recent technologies, namely blockchain. To this extend, a design and example of how actors along the supply chain could implement blockchain within a context of continuously evolving technologies is laid out.

Chapter III. Methodology and Plan

The first part of this thesis will be a review of the literature based on existing research papers, recent developments and initiatives. First the soy industry and its need for traceability will be reviewed, by highlighting the pain points in the current soy supply chain and analyzing the current initiatives for sustainable soy. Secondly, an introduction to blockchain and its potential implementation within the soy supply chain will be reviewed. Lastly, a concrete application will be presented and reviewed.

The second part of this thesis will present qualitative research and analysis done with different actors linked to the soy supply chain: retailers, FMCG companies, end consumers, soy certifications schemes and experts. By presenting the systemic approach, a comparative analysis will be done based on the different interviews to assess current situation, motivations, and constraints toward more traceability via blockchain.

The final part of this thesis draws an overall conclusion of the literature review and qualitative research. Finally, limitations of this work will be presented and suggestions for future research.

Part I. Literature Review

Chapter I. The soy industry and its need for traceability

The main aim of this first chapter is to describe the soy industry and its need for increasing traceability in the supply chain. This chapter will allow the reader to understand the key elements of the research question, who will then be able to understand the bigger picture and purpose of the overall research. Furthermore, the question of why actual traceability tools are not sufficient will be addressed in order to clarify the urgency of the problem.

Section 0. Definitions

Before diving into the subject, this first section will define the terms used all along this thesis.

First, and foremost, let's define "traceability". According to the International Organization for Standardization (ISO) (2021) **Traceability** is the ability to follow the movement of a feed or food through specified stage(s) of production, processing and distribution". It is the principle of "one step back, one step forward" and can recall information about the origin of a food product. In Europe, a legislation regarding traceability has been developed. Regulation EC No 1830/2003 oversees traceability and labeling requirements of GMOs and the traceability of food and feed products produced from GMOs (EurLex, n.d).

In order to have a good understanding of the traceability of soy, it is important to understand the supply chain and therefore define this concept. **Supply Chain** is " *a network of materials, information and services processing links with the characteristics of supply, transformation, and demand* " (Chen and Paulraj, 2004 cited by Felea and Alb, 2013) or described by Mentzer et al. (2001) (cited by Felea and Alb, 2013) as " *a set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances and/or information from a source to a customer* ".

In addition to this definition, it is also crucial to define Supply Chain Management (SCM). According to Oliver and Webber (1982) defined as " the process of planning, implementing and controlling the operations of the supply chain with the purpose to satisfy customer requirements as efficiently as possible " (cited by Felea and Alb, 2013).

Section 1. Defining our scope : The soy industry

Soy is one of the most important food commodities in the world, it is a particularly versatile commodity that can fulfill multiple purposes. Since the early 1990's, global production levels have tripled and this trend is expected to continue due to changes in consumer behaviors and population growth (Czaplicki et al., 2019) (Figure 1). Worldwide, soy production rose from 100 million tons produced annually in the early 90s to 362 millions in 2018. (Tillie & Rodriguez-Cerezo, 2015) Approximately a third of soybeans imported to the EU (European Union) stems from Brazil and 80% of soymeal comes from Brazil and Argentina (Czaplicki et al, 2019) While soy production in the USA remained quite consistent, the area of plantations in Brazil increased from less than 10 million to more than 38 million ha (Guerrero et al, 2021). These high production rates are accompanied by multiple domestic policy reforms in both countries, shaping the export-oriented nature of the soy expansion. In the case of Brazil for example, and since the election of Bolsonaro, policies for expanding agribusiness development led to an expansion of soybean exports to the detriment of environmental protection.

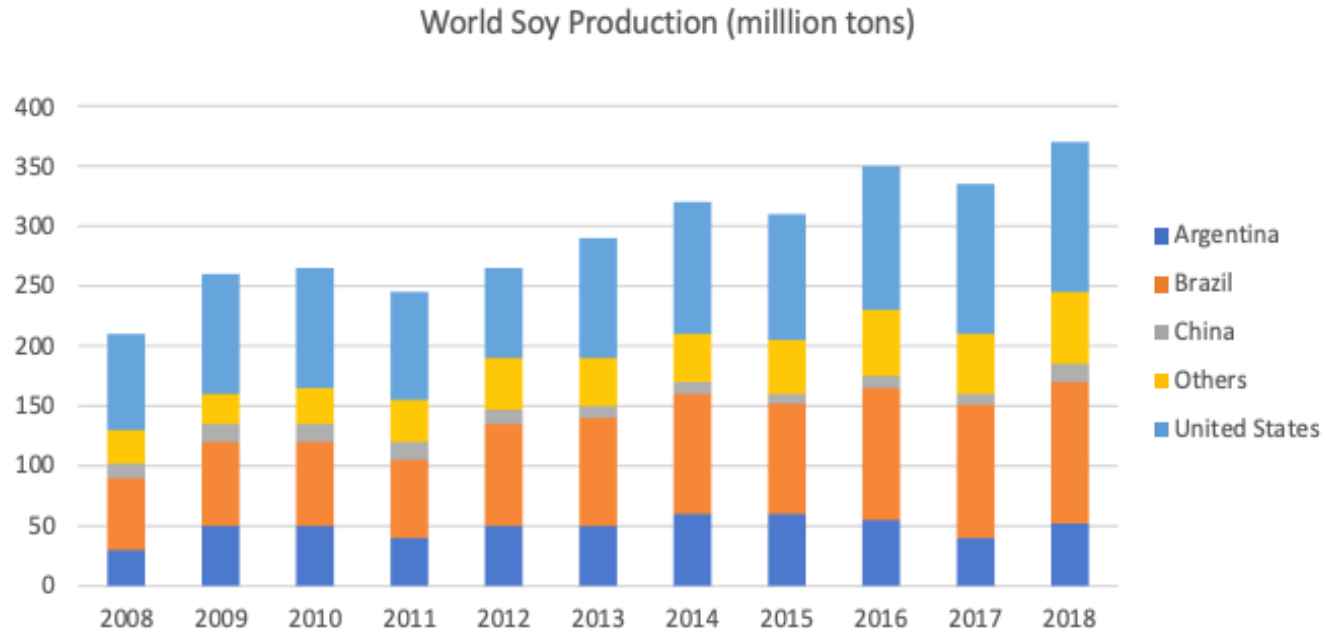


Figure 1 - World soy production (millions tons) (Czaplicki et al., 2019)

The soy market in the EU however, evolved quite differently (see Appendix 1). From 2007 to 2017, EU imports have remained flat with about 35 million tons imported on an annual basis (Czaplicki et al., 2019). The EU is looking to gradually reduce dependence on imports by promoting more local productions. Already grown in many parts of Europe including Austria, Italy, France and other countries, local soy production could become a promising alternative to meat if meeting the global demand. However, in 2018, the EU28 only produced 2.7 million tons of soybeans grains and is therefore still compelled to import a massive quantity of soybean.

Section 2. The economics of soy

I. End uses of soy

Soybeans are essentially composed of 80% meal and 20% oil. A 60-pound bushel of soybeans yields almost 11 pounds of soybean oil and 47 pounds of soybean meal. Despite the notoriety of soy-based food products, the majority of soybean production is used in other ways than in the food industry. (ncsoy.org, n.d) Figure 2 illustrates the end uses of soy.

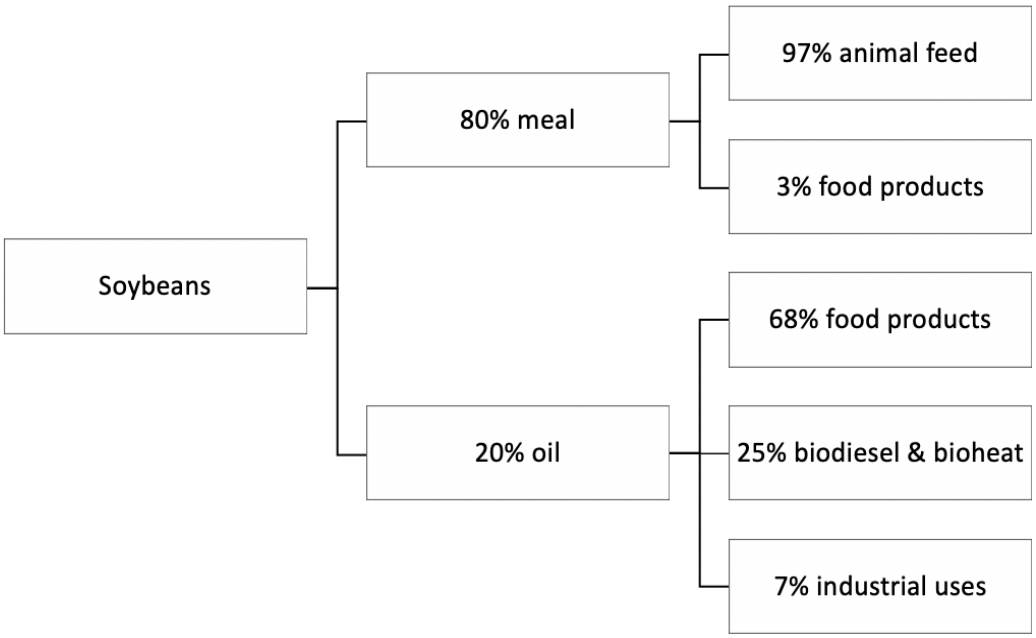


Figure 2 - Uses of soybeans

The soybean meal (80%) that remains after oil extraction can be used for different applications:

- 97 % is used for animal feed. As soybean meal is high in protein content, it is a major ingredient for poultry, pigs, cattle and other farm animals.
- 3% is used for **food products.** Only a small part of the soybean meal is used in food products like protein alternatives and soy milk.

The other portion extracted from soybean processors is oil (20%) and can serve for multiple purposes.

- 68% of the extracted oil is utilised for **food products.** Indeed, it can be used as cooking oil or used as an ingredient in food products such as margarine, salad dressings or mayonnaise. Breads, crackers but also cookies or pies can contain soybean oil.
- 25% is used for **biodiesel and bioheat.** By processing soybeans via a process of transesterification, soybean oil can be used for diesel engines. This alternative to petroleum-based fuel, is more environmentally friendly as it reduces particulate emissions, and it is non-toxic and renewable.
- 7% is used for **industrial uses** such as paints, plastics, or cleaners.

This thesis will discuss the application of soy used in food products. This decision was made based on the author's interest in soy food products and the increasing trend towards vegetarian diets.

II. Food industry

In the last decades vegetarian diets have become more popular among the population for different reasons including ethical, ecological and health purposes. Because soybeans are high in protein content, and low in carbohydrate content, they are characterized as a unique vegetable protein source compared to other vegetables. (Rizzo & Baroni, 2018) Many food companies including Danone, Nestlé or Unilever offer increasing products containing soy. The reasons for this increasing use for food application is multiple. First, as mentioned before, soy increases the overall nutritional value of food products thanks to its favorable ratio of unsaturated fatty acids to high protein content. It can therefore be categorized in the group of products with special health or dietary properties and contributes to the expansion of its growing use in human food. Furthermore, soy also has some functional properties enhancing the appearance, texture, or consistency. Indeed, by using them to emulsify fat and bind water,

many products' moistness is kept without affecting other ingredients. Lastly, besides being versatile and flexible, soybeans can be used by food companies for cost purposes. Soybeans are one of the cheapest crops to grow and thrive in a wide variety of climates.

Section 3. From soy seed to end consumer – the entire value chain

The supply chain for soy is complex, made of multiple actors and diverse links between them. Understanding its complexity is essential for increasing traceability at all stages. Figure 3 illustrates a simplified version of the soybean supply chain with its main phases and actors. Below a description of soy flow produced in Brazil will be reviewed.

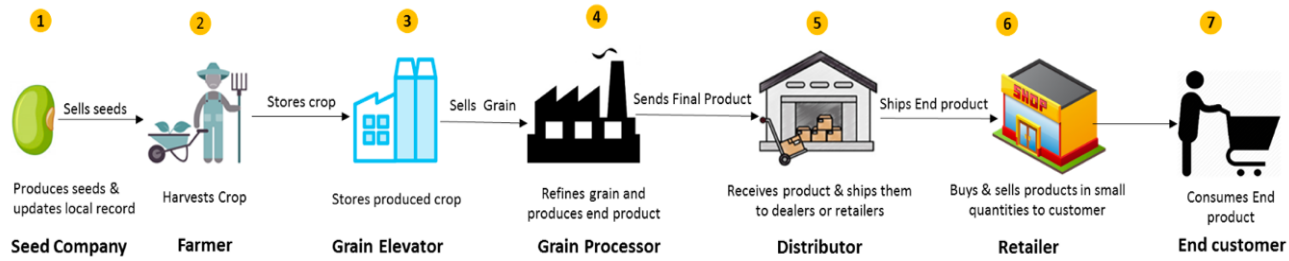


Figure 3 - The product flow in the soybean supply chain (Salah et al., 2019)

The soy goes through different life cycles stages:

1. The **seed company** produces and sells the seeds to the farmers. Then, the seeds are transported to soybean farmers: including large soy farmers, co-operatives or small and medium farmers.
2. **The farmer** harvests the crop and sells this to the grain elevator. The farmer uses raw and organic material (fertilizers, seeds, ..) to grow the soybean crops. In Brazil, the farmer can make sure the crop is sustainable by registering to the Rural Environmental Registry to obtain the CAR registration.
3. The **grain elevator** who buys the crop is responsible for determining whether he is introducing sustainable soy into the product chain. To achieve environmental compliance, the grain elevator should make sure the farmer is CAR registered as there is a significant risk that soy production without CAR registration is linked with illegal deforestation (Vasconcelos et al., 2019).

4. The **grain processor** refines the grain and produces the end product. During the packaging phase, batch labels are carried out, containing information such as the production day or list of raw materials used. The end product is transported to the distributor.
5. Once packaged and labeled, the **distributor** receives the product and either stores it depending on the delivery time or ships it directly to dealers or retailers.
6. The **retailer** buys and performs the sale of the products in small quantities to the customer.
7. The **consumer** is the end user of the chain and can ask for any traceable information regarding quality standards, country of origin, production methods, ingredients etc. before consuming this end-product.

Section 4. The need for traceability at production, trade and consumption stage

The soy supply chain faces unprecedented challenges concerning human health, soy security and safety, deforestation and climate change. To address these challenges, it is increasingly important to ensure transparency and traceability for all actors in the supply chain. This section examines how traceability could improve environmental and socio-economic impacts at different stages of the supply chain. For simplicity reasons, we will consider only three stages of the supply chain, namely (I) production, (II) trade, and (III) consumption.

*I. The need for more traceability at **production stage***

Environmental issues

At the production stage, increased traceability could improve environmental issues**.** Indeed, soy is one of the prominent drivers of deforestation. Going back to the early 2000s with high deforestation rates, annual deforestation rates decreased from approximately 2.7 million ha in 2004 to 0.5 million ha in 2012 in Brazil (Gollnow et al., 2018). The principal factors explaining this declining rates in deforestated area are commonly understood as a combination of zero-deforestation supply-chain commitments, declining commodity prices and implementation of environmental strategies. The Soy Moratorium in Brazil for example, was the first voluntary implementation of a zero-deforestation agreement in the tropics, prohibiting imports of soy from deforested agricultural zones after July 2006 (Leong et al., 2018). Other initiatives include

the use of satellite imagery to identify deforested areas. Overall, these strategies drastically reduced deforestation, conserving approximately 7.3 million hectares of Amazonian Forest between 2005 and 2009. (Gollnow et al., 2018) However, deforestation rates in the Brazilian Amazon have grown since 2013, rising from about 0.5 million ha in 2012 to 0.7 million ha in 2017 (INPE, 2018). Concerns about these measures and techniques' effectiveness are growing, and better traceability systems could therefore help to curb deforestation.

In addition to deforestation, conversion of native vegetation to soybean agriculture also increases precipitation runoff in the forest areas, resulting in a dry local climate. As this destroys the livelihoods of indigenous people and local forest-based communities, soybean expansion also indirectly contributes to this through their relocation (Czaplicki et al., 2019).

Lastly, soybean cultivation in some areas is highly reliant on irrigation systems and high water consumption, which can result in water shortages in producing areas, particularly during climatic occurences such as El Niño. On top of this, the soil preparation and manufacturing of agricultural products such as herbicides and fertilizers for the production phase emit greenhouse gas emissions and implies a poor quality of water bodies in producing regions. The conventional use of herbicide is also related to the negative health effects on farm workers as well as negative environmental impacts on biodiversity and ecosystems. (Czaplicki et al., 2019)

Socio-economic issues

Socio-economic issues could also be alleviated with better traceability at production stage. Soy producing countries such as Brazil or China are frequently associated with illicit labor and poor working conditions. Agricultural workers operate in poor circumstances, face health and safety hazards and have insufficient training and safety guidance. (Czaplicki et al, 2019) Leveraging traceability could not only contribute to increased transparency in workers' rights and employment intensity but also to enhanced community engagement for small cooperatives of farmers. With a more trustworthy cooperative of farmers, smallholders could earn a bigger share of the value of the crops they cultivate and therefore sell them at higher prices. An increased transparency of product information could also solve problems among farmers in more equitable manner. (Kamilaris et al, 2019)

*II. The need for more traceability at **trade stage***

Environmental issues

With the increased traceability and identification of soy's production location, environmental impacts in terms of greenhouse gas emissions can also be reduced during trade stage. The transport phase of soybean products generates significant emissions. According to a recent study (Czaplicki et al, 2019), transport from Brazil to the EU increases emissions compared with domestic deliveries. Road and maritime transports leads to increased emissions of nitrogen oxides which leads to acidification and eutrophication of oceans. Both cause increased toxins and reduced diversity, harmful for the oceans.

*III. The need for more traceability at **consumption stage***

Environmental issues

At the consumption stage, increased traceability could also improve environmental issues. By ensuring that all consumers have the relevant information and awareness for sustainable development and lifestyles in harmony with nature, responsible consumption and production would be enhanced. By promoting sustainable practices consumers will gain awareness and pay increased attention to soy's sourcing and production processes.

Sustainability issues

By using technologies able to track and trace products, firms will also be incentivized to invest in their overall triple bottom line strategy. Companies will invest in their overall sustainability, by ensuring stronger human rights, fairer labor standards and a greater focus on environmental implications while improving their long term profitability. Indeed, by increasing the value of business assets, food companies can incur cost reduction in the long term. Unilever for example pursued a year-long pilot project with a British grocery retailer and packaging company in order to manage transactions within the tea supply chain among 10 000 farmers in Malawi. Partners along the supply chain were able to track products, validating the sustainable agricultural practices requirements of tea farmers, and rewarding them appropriately. Farmers get better pricing by using methods designed to increase harvest without using more land. This initiative is one of the numerous examples, incentivizing

sustainable farming practices by rewarding sustainable sourcing and smallholder farmers. (Tapscott & Tapscott, 2016)

Socio-economic issues

Socio-economic problems at the consumption stage could also be solved with more traceability.

Since the soybean industry is separated into two different categories, the genetically modified organism (GMO) soy and the non-genetically modified organism (non-GMO) soy, traceability could ensure **food integrity, by preserving** the identity of the crop along the supply chain. According to the European Commission (2021), genetically modified organisms are defined as *"organisms whose genetic make-up of living cells and organisms are being modified, by using techniques of modern biotechnology."* Worldwide, 80% of soybeans are planted with genetically modified varieties, and this trend is expected to increase (Tillie & Rodriguez-Cerezo, 2015). GMO soybeans are mostly found in livestock thanks to their cost-effective source of proteins, while non-GMO soybeans are primarily used for human consumption by food companies. The existence of GMO and non-GMO soy therefore implies that non-GMO soybeans need to be segregated from GMO soybeans in order to ensure that their non-GMO identity is preserved throughout the whole supply chain, from production to end-consumer. Because most of the bulk of agricultural crops are traded as commodities, their harvest, transport, processing and trade is characterized by the aggregation of many consignments into bulk shipments of batches from different origins, making it hard to distinguish crops.

Apart from addressing GMO standards, several issues related to **food safety,** and in particular higher contamination risk, can also be solved with increased traceability. Food safety points to the condition of processing, managing and storing food while ensuring this in a hygienic manner in order to prevent the occurrence of diseases (Kamilaris et al., 2021). Despite governments and health organizations attempts to prevent outbreaks, during past years, various epidemic incidents have been reported. In the USA the Yerslnle entercolltla outbreak in contaminated tofu and various incidents have already been reported (Tacket et al., 1985). Consumers want to become more and more aware of the quality of food they consume and will likely require the traceability information before purchasing a product in the future (Subramanian et al., 2020).

Thirdly, traceability could also provide a summary of information about the food ingredients and origins and thereby help downstream companies for their **labelling**. Regarding GM food, labelling is required on every product except for GM food products which include a proportion no more than 0.9 percent of the food ingredient assessed individually or if their presence is accidental or unavoidable (European Commission, 2016). Traceability could therefore enable tracking GMOs and GM food/feed products at all stages of the supply chain and monitor detrimental environmental or health consequences. Where necessary, it could allow the withdrawal of soy-containing products if unforeseen dangers are discovered.

Section 5. Current traceability tools in the soy supply chain

This section will briefly give an overview of two important wireless technologies (Radio frequency identification and Wireless Sensor Networks) already in use in the soy supply chain system to increase traceability, while explaining the potential pitfalls.

Radio frequency identification (RFID)

The RFID technology is one of the prevalent technologies which is increasingly used for food logistics and supply chain management. By providing real-time information and not requiring eye contact, it provides several advantages over existing technologies such as barcode and data loggers. It can be placed in an item, embedded inside a packaging or injected inside the body of an animal. (Ruiz-Garcia & Lunadei, 2011) RFID technology enables us to connect the physical world material with their visual counterparts, resulting in an automatic traceability. More concretely, RFID systems are composed of RFID readers and RFID tags. Tags are attached to an asset while the RFID reader continuously sends Radio Waves. Whenever tags are in the range of the RFID reader, data is transmitted to the reader. It is quite similar to barcodes, except that RFID readers do not require to be in line of sight to the tags. RFID readers are able to capture information as long as the asset is in the range of the reader. Range and performance of the reader depends on the type of RFID used. Besides, one single reader can track multiple objects at the same time. This technology has already been proven to be successful in many applications including agriculture. It can play an important role not only at production and processing stage but also during transportation, storage and distribution. By

attaching tags to batches of soy, data including location, temperature, or package weight could be captured. (Kumar, 2018)

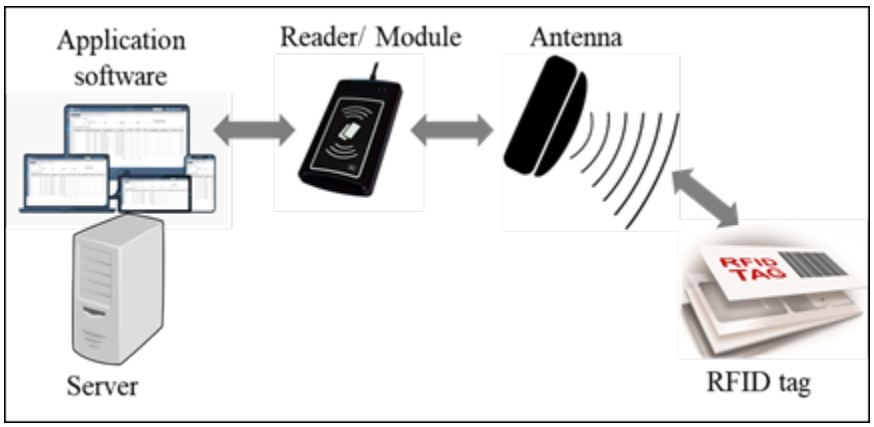


Figure 4 - RFID tag (Jituri, 2020)

RFID and other existing technologies like as barcodes have the disadvantage of being universally readable. This means that anyone with an RFID reader can read the sensitive data stored on RFID tags, posing a data security problems. RFID is also hackable, and data can be manipulated. In addition, even though RFID and barcodes are used in reverse logistics, companies cannot monitor the status of their returns to multiple stakeholders. As a result, it is difficult for logistic service providers to judge the quality of returned products. A final problem associated with RFID technologies is that they generate massive volumes of data, which creates pressure on the database both in terms of speed and volume to handle. An RFID implementation can generate much more information than traditional barcode technologies. A potential solution to this lies in implementing a decentralized data system in order to store all information. (Ruiz-Garcia & Lunadei, 2011)

RFID tags can be replaced or supplemented using wireless sensor networks (WSNs). A wireless sensor network (WSN) is made up of wireless sensors and actuators like humidity, temperature, sound, and pressure sensors. These sensors communicate with an external system, which stores and distributes data to stakeholders. Information such as wind speed, plant diseases, temperature, humidity, and insect pests etc. can be provided. There are many different sensor nodes. Based on their size and complexity, their level of energy, storage, and computing speed is determined.

Because sensors are quite different from each other, it is difficult to obtain a homogenous environment in large sensor networks. This leads to a number of problems in integrating, storing and sharing data information. Moreover, as some nodes have limited storage capacity, they give up on data resulting in a loss of information for the entire network. (Ren et al., 2018) Appendix 3 illustrates the WSN for agriculture.

All in all, it has been illustrated that current traceability systems are not able to quickly and reliably provide information on the origin of the product and lack transparency and consumer confidence. In addition to technical and operational problems, actual systems suffer from a lack of standardization around data, labeling and packaging, and units of measurement but also from low technology capacity for selected actors, and the mixing of batches and re-batching of soy products. Lastly, in addition to data fragmentation, governance is decentralized and interoperability is out of date (Leong et al., 2018).

Section 6. Current initiatives promoting sustainable soy

Today, certification initiatives for soy remain low. For other commodities such as coffee and cocoa, certification labels such as UTZ Certified, or the Rainforest Alliance built responsibility into agricultural production in a viable way. However, the soy industry evolved quite differently, because the certified soy remains a niche market and represents only 2 to 3% of global production (KPMG, 2013). Several certifications and labeling organizations are active including Roundtable on Responsible Soy (RTRS), International Sustainability or Proterra. Due to a lack of time and based on WWF reference for RTRS for responsible soy, only RTRS certification and Proterra, two largest world soy certifications, will be discussed (KPMG, 2013) (Czaplicki et al., 2019).

I. Roundtable for Responsible Soy

The Round Table for Responsible Soy (RTRS) established in 2006, has been recognized as voluntary scheme for promoting sustainability criteria's in the soy supply chains (European Commission, 2017). Civil society actors but also major soybean supply chain actors participate in this initiative. The RTRS adopted a certification standard to ensure that soy is produced in an *" environmentally correct, socially appropriate and economically viable process,*

deforestation and conversion-free" way (*Certifications – RTRS*, n.d.). Currently, RTRS offers two certifications:

- **The RTRS certification for Responsible Soy Production**, which verifies that soybeans are produced in compliance with specified socioeconomic and environmental standards. It has a five-year validity period and is reviewed once a year. (*Certifications – RTRS*, n.d.)
- **The RTRS Chain of Custody (CoC) Standard,** which requires companies to ensure traceability along the supply chain. This standard applies to the entire supply chain and is required for firms receiving, processing and trading RTRS soy. (*Certifications – RTRS*, n.d.)

II. ProTerra

ProTerra is an alternative and somewhat less demanding certification that has been developed by the ProTerra Foundation. This standard, which applies only to non-GMO crops, commits to improving transparency, traceability and environmental impact throughout the entire soy supply chain. According to Kusumanigtyas (Czaplicki et al,2019), its 2018 version performed slightly less regarding deforestation, biodiversity, and wetlands conversion than RTRS standards. Multiple food companies are included in the ProTerra Network including Alpro Comm. V.A., Barry Callebaut or Cargill (The ProTerra Network, n.d.). This certifications scheme consists of two elements:

- The ProTerra Certification Standard: The objective of this standard is to encourage good agricultural practices, guarantee the sourcing of sustainably produced and fully traceable non-GMO ingredients for feed and food, preserve the environment and promote fair labor and local communities. The certification is applicable at distinctive levels of the supply chain: from the agricultural production level, to transport, storage traders and dealer level, ending with the industrial processing level. (ProTerra Certification Protocol V3.0, 2019)
- The ProTerra Certification Protocol: this Protocol was set up for certification bodies, auditors and economic actors. It defines the process and procedures to follow for certification against the ProTerra Standard. (ProTerra Certification Protocol V3.0, 2019)

Chapter II. How blockchain could improve traceability in the soy value chain

The previous chapter outlined the urgency for more traceability along the entire supply chain. This chapter will introduce blockchain as an additional tool to current technologies, and provide an overview of the different characteristics of the two most leading industry platforms, namely Ethereum and Hyperledger. Furthermore, this chapter ends by comparing both alternatives.

Section 1. Introduction to blockchain

Blockchain is one of the disruptive technologies which can provide an innovative solution for product traceability in agriculture and food supply chain. With its potential to track, trace, authenticate products, secure information, save transactions and contracts, it can be used throughout the entire value chain (Walton & Perkins, 2018). In a collaborative blockchain network connecting farmers, manufacturers, merchants and distributors, traceability information about product origin but also possible allergies or added substances can be stored. These blockchains providing a secure and irreversible way to store information can be used across multiple organizations in different countries. Blockchain offers the ability to establish a trusted information flow between different stakeholders with particular agreements. (Demestichas et al., 2020) According to the Vice President of Product for Sage Business Cloud, Robert Sinfield : "*On the visibility side, blockchain ERP systems could enable everyone involved to track the product's journey from the manufacturing floor to the retailer's shelf, without having to worry about records being lost or tampered. Nowhere is this more prevalent than in the food and drink space, where blockchain will provide transparency and product provenance that is validated from farm to fork*" (Wattanajantra, 2020).

Some background for what we nowadays refer to as "blockchain" was first presented by Satoshi Nakamoto's white paper in 2008. He established bitcoin as a cryptocurrency and designed the first blockchain database. According to Raikwar et al. (2019) a blockchain is: " *a type of distributed ledger technology (DLT) maintaining a continuously growing list of data records that are confirmed by all of the participating nodes."* Blockchains are constructs of chronological blocks and refer to a highly scalable, decentralized peer to peer (P2P) network.

(see Figure 4) According to Cope (2002) a P2P network is " *created when two or more PCs are connected and share resources without going through a separate server computer*. "
In the blockchain, each block contains a record of data, the value of the previous block's hash, the value that represents its own hash and the number of the block. The first block is the genesis block, and the following blocks are added through distributed consensus along with cryptographic footprint and timestamp. Appendix 4 shows the transaction in the blockchain. Blockchains are immutable meaning that if anyone tries to tamper or corrupt the data of a specific block, changing the hash of this block will result in a cryptographic link disruption. A change in one block will result in all other blocks not being valid anymore, therefore resulting in a disruption in the chain with blocks not connected anymore. Blocks therefore provide a reliable, safe and near real-time record of transactions among parties.

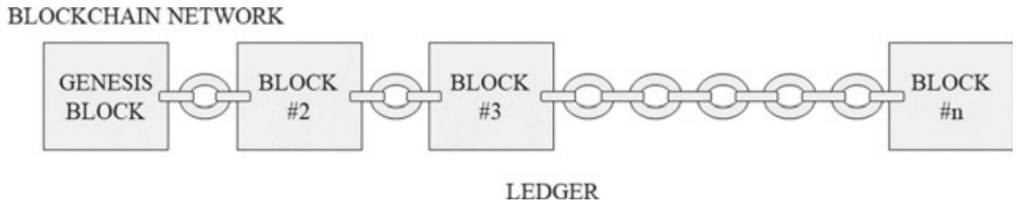


Figure 5 - Blockchain network represented (Subramanian et al., 2020)

Before diving further into the blockchain, the different parts of a blockchain need to be explained.

- A **hash** is the digital fingerprint of the block, which is the output of an algorithm that turns the content of the block into a random combination of letters and numbers. Users can trust that the data has not been tampered by matching the hashes with the expected values.
- **Nodes** are in charge of ensuring the accuracy and reliability of data stored in the distributed ledger. They form the infrastructure of a blockchain and are all linked to each other. When a new block is added to the blockchain, nodes can accept or reject the new block. When a block is accepted, nodes save and store the new block on top of the rest of the blockchain.
- **Consensus** means to reach agreements among network nodes or systems, according to the interest of the system participants. Participants in a blockchain network

collectively follow a consensus protocol to agree on distributed ledger content of transaction, cryptographic hashes and unique digital signatures to ensure integrity of transactions. All blocks validated via the consensus mechanism are linked together from the first to the last confirmed block, forming the blockchain. (Motta et al., 2020) Different mechanisms are used to establish consensus depending on the implementation and use case.

- **Reliable and secure**: as several participants share a blockchain, blockchain is resilient to failures or attacks (Walton & Perkins, 2018)
- **Near real time**: settlement of recorded transactions happens almost instantly, thereby removing the friction and reducing the risk. (Walton & Perkins, 2018)

Section 2. Characteristics of different blockchains

I. Blockchain type : Private, public, consortium, and hybrid blockchain

Blockchains are not all the same type. In this thesis, three different approaches will be analyzed : public blockchain, private blockchain and hybrid blockchain. This section will review each type of blockchain.

The first type of blockchain, the **public blockchain**, also called permissionless blockchain, allows anyone to participate, read and write data on the blockchain network without any authorization. These public blockchains such as Bitcoin, Ethereum or Lisk are not controlled by third party organizations. People have full access to data which ensures complete transparency and a high level of anonymity. By using a distributed “open ledger”, every participant competes for the right to generate new blocks. (Wang et al., 2020) It is very secure and practically impossible to corrupt because transactions are confirmed by every participant in the whole network. (Subramanian et al., 2020) It is however slower and less efficient than private blockchains since all participants on the network must reach consensus.

The second type of blockchain, **the private blockchain**, also known as permissioned blockchain, refers to a closed and partially or completely centralized system. This second type of network is fully controlled by an organization or institution, and the data access is regulated by the organization. This central authority has the power to regulate and consolidate networks

and grant access to participants to view, read, write or validate transactions on the blockchain. This highly efficient type of blockchain is used by many companies to maintain their autonomy and hold certain information private from the public. Since private blockchains have fewer participating nodes with fewer constraints, time to reach consensus is shorter, transactions are faster faster, efficiency is higher and the cost is cheaper. (Wang et al., 2020) Hyperledger Fabric, Hyperledger Sawtooth, Ripple and Multichain are examples of private networks. (Demestichas et al., 2020)

Hybrid approaches, also called **consortium blockchains**, exist and refer to a combination of the private and public blockchain. It can have a private permission-based system as well as a public permissionless system. A preset list of participants - enterprises or government entities - is in charge of the consensus process, they can either allow the public to view data or restrict access to its members. (Subramanian et al., 2020) Companies can benefit from using a private ledger to secure transactions with business partners while also using an open ledger to share product information with customers. Hybrid blockchain is appropriate for B2B transactions and is equivalent to private blockchains in terms of cost and efficiency (Wang et al., 2020). Consortium blockchains allow flexibility to invite more actors into the blockchain, companies can easily join a private blockchain with multiple public blockchains. Examples are Dragonchain, XinFin and Libra. (Subramanian et al., 2020)

	Public blockchains	Private blockchains	Consortium blockchains
Type	Public - no centralized entity	Private - single authority	Multiple organizations
Determination of consensus	All participating nodes	Only one organization	Designated set of nodes
Efficiency	Low	High	High
Fault tolerance	High	Low	Moderate
Examples	Ethereum	Hyperledger Sawtooth	Hyperledger Fabric

Table 1 - Comparison of public, private and consortium blockchain (Wang et al., 2020; Caro et al., 2018)

II. Consensus mechanism

When choosing a blockchain platform the consensus model is likely the most important factor to consider. It ensures that all participants agree on the network's state while regulating operations on the network like adding transactions and incentivizing the participants to behave correctly. There are several ways to reach consensus, in this part, only the two most used consensus algorithms will be developed, namely **proof-of-work (PoW)** and **proof-of-stake (PoS).** PoW consensus algorithm was chosen as it works well in an open environment where any number of nodes can participate and start mining, while the PoS consensus overcomes the drawbacks of high power consumption caused by mining in the PoW algorithm (Baliga, 2020). Other consensus mechanisms include Proof of Elapsed Time (PoET), Simplified Byzantine Fault tolerance (SBFT), Proof of Authority, and Delegated Proof of Stake (DPoS). An overview of different consensus algorithms with their performance and limitations is given in Appendix 7.

The first type of consensus mechanism is transactions based on a **proof-of-work (PoW)** consensus mechanism. To add blocks to the blockchain, PoW imposes a complicated problem that needs to be solved by participating nodes. The node has to find the hash value of the block header. The process of solving this PoW puzzle to find a winning hash value is known as **mining**. Miners who solve the puzzle will be granted access to add their proposed block to the blockchain. It could happen that sometimes more than one node is able to find the correct hash at the same time. When both winning nodes add their own proposed block to the blockchain, a fork is created in the blockchain. This is temporary, while more blocks will be added to these forks, the protocol will ensure that the branch with the maximum PoW will be included in the blockchain, while the other will be discarded. (Baliga, 2020) PoW consensus is however vulnerable to "51% attacks" or "majority attack", where a miner or a group of miners obtain 51% of the hashing power, thereby manipulating the blockchain. (Demestichas et al., 2020) With this much firepower, hackers could double spend their own funds, reverse transactions, or deliberately reject transactions they do not want to include in the blockchain. (Tapscott & Tapscott, 2016) A successful majority attack also prevents old transactions from

being confirmed or miners from mining, which results in a mining monopoly. As blockchain is a distributed network of nodes where all participants participate in the process of consensus, the larger the network becomes, the stronger it is and the less likely a 51% attack will happen.

Proof-of-stake is another type of consensus mechanism, more decentralized than PoW. PoS does not allow every user to mine for new blocks and is less expensive compared to the PoW mining equipment requirement. The network is also more secure as it stimulates more people to set up a node (Demestichas et al., 2020) In a PoS protocol, users are selected based on their stakes in the blockchain, i.e their contribution to the blockchain network. Nodes are called validators, and instead of mining, they validate the transaction to gain a transaction fee. (Kamilaris et al., 2021) This alternative mechanism achieves the same effect of mining (distributed consensus) without consuming as much energy as the searching process involved in the PoW.

III. Blockchain platforms

Companies are also typically faced with a "make-or-buy" decision when choosing their blockchain platforms. They can develop their own blockchain platform in-house or join an existing open-source blockchain network. Companies can decide to develop a blockchain network **in-house** and deploy their own blockchain platform, becoming the blockchain application provider and blockchain service provider. (Subramanian et al., 2020)

Another option for companies is to opt for the open source blockchain network. This service, referred to as **Blockchain-as-a-Service (BaaS**), allow consumers to use cloud-based services to create, operate and host blockchain apps, functions and smart contracts. On one hand, more and more companies started offering this service observing the increasing potential of blockchain applications. On the other hand, providers such as IBM, Microsoft Azure and other large companies decided to provide this BaaS in order to facilitate blockchain implementation for other organizations. Food companies could thereby focus on their core competencies instead of worrying about the development of the blockchain. But how does BaaS work? Concretely, providers set up and manage a blockchain platform and technology for their customers in exchange of a fee. Companies create and run their own public or private blockchain on this open source blockchain platform provided by the BaaS companies. The service offered could differ in terms of functionality, infrastructure, cost and scalability. BaaS

models gain increasing attention thanks to their reduced developing costs, risk and time to market for testing and launching blockchain applications (Subramanian et al., 2020). As mentioned earlier, one of the major BaaS providers, Microsoft Azure offered some of the leading industry frameworks of blockchain platforms for companies. In the next section some of them will be reviewed.

Section 3. Comparing two most industry leading platforms

While blockchain is a powerful technology, it is not a one-size-fits-all. Indeed, since every enterprise has different needs, blockchain needs to have different features to achieve its intended purpose. In the past years, different blockchains with different features have been developed. In this section the industry's most leading blockchain platforms will be reviewed, namely Hyperledger and Ethereum. Demestichas et al (2020) provide an overview of research works about different agriculture traceability systems, where the majority have used Ethereum or Hyperledger. (See Appendix 6) Those two publicly available blockchain platforms can integrate various IoT devices, which enables the direct transfer of data in the blockchain. Moreover, both implementations enable a high level of customization for the records included on the ledger. Last, comparing both, Ethereum works with a single transaction structure, while Hyperledger Sawtooth allows the definition of a custom transaction structure. (Caro et al, 2018)

I. Hyperledger Sawtooth

Hyperledger was created in 2015 when different companies interested in blockchain decided to work together to be more competitive. By assembling their resources, they created an open-source technology that anyone could use. Hyperledger is a private blockchain hosted by the Linux Foundation and has grown rapidly in the recent years. By offering their blockchain software to enterprises, Hyperledger brings together users, developers, and vendors from different sectors and market spaces. All Hyperledger projects follow the same design and require five characteristics:

- Modular: Hyperledger has created a modular, extendable framework with common reusable building blocks. Developers can work on numerous projects at the same time and re-use common modules.
- Highly secure: Security is a critical factor to consider in distributed ledgers, especially for users dealing with high-value transactions or sensitive data.
- Interoperable: In order to meet the expanding usage of blockchain, applications and smart contracts should be transferable across many blockchain networks.
- Cryptocurrency-agnostic: Hyperledger projects are independent from alt-coins, cryptocurrencies and tokens and will never issue its own cryptocurrency. (*Hyperledger.org* , 2018)

Within the Hyperledger blockchain family we can distinguish five different frameworks; Hyperledger Burrow, Hyperledger Fabric, Hyperledger Iroha, Hyperledger Sawtooth and Hyperledger Indy. (See Appendix 8) Due to a lack of time, this thesis will only dive into Hyperledger Sawtooth as this is the most common Hyperledger used in the majority of research works in agriculture traceability systems (Demestichas et al, 2020).

Hyperledger Sawtooth is a distributed ledger providing digital records maintained without a central authority or implementation. Being enterprise oriented and highly modular, Sawtooth wants to keep ledgers distributed and make smart contracts secure for enterprise use. This enables businesses and consortiums to make their own decisions about their blockchain applications. (*Hyperledger.org*, 2018)

II. Ethereum

Ethereum is one of the most industry leading public blockchains. This permissionless blockchain, provides a decentralized Ethereum Virtual Machine to process P2P contracts through its dedicated cryptocurrency Ether. According to Wang et al (2020), Ethereum architecture can be divided into three layers: underlying services, core layer and top-level applications. (See Appendix 9)

The P2P network services, Level DB database, encryption techniques, and fundamental features like sharing optimization are all part of the underlying service. In the P2P network,

nodes are vital components as they send and receive messages with transactions and blocks to achieve consensus. The LevelDB database stores the Ethereum blocks, transactions and other data. Lastly, in order to maintain privacy and security of data in the blockchain, cryptographic algorithms are used. (Wang et al., 2021)

The core layer includes core elements such as the blockchain, consensus algorithm and EVM (Ethereum's virtual machine). The blockchain forms the main body, supplemented by Ethereum's unique consensus algorithm. EVM is the runtime environment for the computations on which user programs are executed and is used to run smart contracts. This ground-breaking tool creates the operating environment of smart contracts becoming more suitable for complex business logics (Wang et al, 2020).

Lastly, the top-level applications contain API interfaces, smart contracts, and Decentralized Application (DApp). All layers together cooperate with each other to form the Ethereum system.

III. Discussion

Related work found in the literature on Hyperledger and Ethereum will be reviewed in this section. While literature about blockchain in other industries has been gaining in popularity, literature in food and agriculture blockchain applications has recently started and is still limited (Caro et al, 2018).

Caro et al (2018), developed a blockchain-based traceability solution tracking products from farm to fork by integrating data from IoT (Internet of Things) devices along the value chain directly in the blockchain. They assessed the performance by comparing the Hyperledger Sawtooth implementation with the Ethereum one. By configuring both networks with default settings, they concluded that Hyperledger Sawtooth had a better performance with respect to the Ethereum counterpart. Even if both implementations have different properties and capabilities as seen above, Ethereum has high reliability and scalability as it enables larger numbers of participants, and its software maturity is higher. Hyperledger Sawtooth has better

performances in terms of latency, processing power and network usage. Appendix 10 summarizes the average values for both networks.

Similarly, Wang et al (2020) compared 4 different blockchains, including Ethereum and Hyperledger Sawtooth. They also concluded that Ethereum's performance is quite low compared to Hyperledger. Moreover, Hyperledger Sawtooth being highly modular, its customization level may be more suitable.
Table 2 provides an overview of the main differences between Hyperledger and Ethereum.

	Hyperledger Sawtooth	**Ethereum**
Blockchain type	Mainly private	Public
Governance	Linux Foundation	Ethereum developers
Platform	Modular	Generic
Latency, network usage, CPU load	Better (Low-latency)	High-latency
Software maturity	Low	High
Participants	Low	High
Economic	High	Can be avoided
Structure for records	Customized	Fixed, single
Logic implementation of smart contracts	Different languages	Single language

Table 2 - Overview of the main differences between Hyperledger and Sawtooth

Section 4. Smart Contracts

A smart contract is a protocol that aims at digitally verifying and carrying out credible transactions that are traceable and irreversible without the intervention of a third party. Like a traditional contract, it enables to regulate trust between parties involved by a collection of organizational terms and conditions. The single distinction is that a smart contract is coded with a programming language (Pranto et al., 2021). According to Schatsky (2016), smart contracts are executed by a computer network that uses consensus protocols to agree upon

the sequence of actions resulting from the contract's code. All actors in a supply chain give increasing attention to smart contracts as smart contracts auto-execute, while all parties validate the outcome instantaneously. Companies can manage the workflow of approvals and automatically transfer payment upon all signatures being collected. This secure and efficient technology avoids paper based systems by avoiding third parties and banks around the world, eliminating physically transferred documents, and increasing the speed of transactions (Schatsky, 2016). The idea of smart contract was set up and implemented in 2016 by Ethereum blockchain. By combining hardware and software, or Ethereum and smart contracts, it has become increasingly challenging to breach and tamper with the contract. Basically, parties agree upon terms and conditions before coding these inside the blockchain.

The building of a typical smart contract involves different steps illustrated in Figure 6.

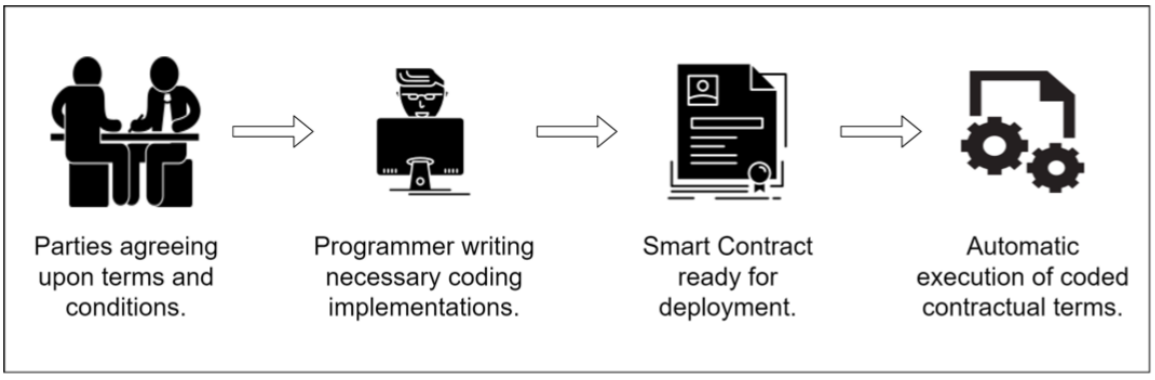


Figure 6 - Steps of building a typical smart contract (Pranto et al., 2021)

The use of these smart contracts can automate the processes in the system, by including real-time tracking of products in the supply chain and comprehensive control of the different stages (Pranto et al., 2021). In the soy supply chain, smart contracts could decrease cost while improving efficiency and reliability. Supply chains are too often hampered by paper-based systems reliant on third parties. Banks or trading parties around the world need to get signatures from all parties before approving transactions, which are processes that can take up to weeks. (Schatsky, 2016)

Coding a smart contract often includes common language terms such as attribute, function event and modifier.

- **Attributes**: Attributes are variables which retain values or information in their memory. Different primitive data can be entered (int, char, string, double), and information such as the company name, field ID, etc can be stored.
- **Functions**: Functions represents the execution of a tasks or mechanisms inside the systems. Once carried out by thousands of mining nodes, the action is executed. They are able to invalidate shipment or processes and put some action to impose penalties on fraudulent stakeholders.
- **Modifiers**: Modifiers represent the authority of actors; they can control or give access power to different actors and components. While the owner of the contract has full modification power, other participants can be given some specific modifications or access to the contract.
- **Events**: Events aim at storing anything in the transaction log of blockchain. They can be triggered by a function to enable participants to continuously monitor, track and get suitable alerts when violations occur.

Section 5. Blockchain as a solution to soy supply-chain issues

More and more evidence prove the usage of blockchain in the supply chain management. According to Chang (2019) blockchain in supply chain management is expected to grow at an annual growth rate of 87% and increase from $45 million to $3314 million from 2018 to 2023. (Cited by Kamilaris et al, 2019) In this section, the main advantages of blockchain in the soy supply chain will be reviewed.

I. Increasing traceability and transparency

While traceability was one of the soy supply chain pain points, blockchain can promote overall traceability by providing a full audit trail of data, creating an everlasting means of record kept along the supply chain. Blockchain enables interoperability between all actors along the supply chain while removing the need to replace their current system. As most businesses don't want to directly integrate or be impacted by another's technology, this is a real game changer (Leong et al., 2018).

By combining RFID or other IoT with blockchain, data such as payment transaction, location of the farmer, quality of the soy etc. could be used in decision making. Blockchain could help for making **sales price** decisions based on product quality for example. (Putri, 2020) By the intermediate of RFID sensors, and with increased transparency, smallholder farmers or producers can access better prices and production control by having greater visibility into downstream demand. By combining location and farmers' identification, compliant soy could also be separated from non-compliant soy and guarantee a deforestation-free supply chain. By tracking the location with the intermediary use of real-time locating systems (RTLS) it could avoid illegal logging.

Besides, **labor conditions** of workers could also be verified across the blockchain, increasing overall transparency. By the use of smart contracts, farmers and laborer's can create a labor contract with specific information regarding payment terms, expected work hours, labor conditions etc. Workers could receive their payment digitally, a transaction which would automatically be recorded to the blockchain and shared with other actors.

Lastly, blockchain could help for improving quality and **avoiding food recalls**. Food and product recalls are a growing concern for food manufacturers or retailers. By the collection of near real-time data, retailers can easily access data and detect problems such as production and expiration dates, lot codes or product order numbers. (Subramanian et al., 2020) (Leong et al., 2018)

II. Security and trust

Another main issue regarding the soy supply chain is related to product fraud, tampering and inaccurate information.

First, regarding data accuracy, even though the initial **data accuracy** is still dependent on the person or the device entering the data correctly in the system, leveraging blockchain makes it easier to identify an issue afterwards (Leong et al., 2018). The approval of every transaction by auditors combined with the timestamping function provides an accurate record of who, what, where and when information uploads on the system. Furthermore, as records instantly update on the blockchain, data cannot be altered or deleted, which

prevents the sensitive data to be hacked by irrelevant parties (Subramanian et al., 2020). By combining blockchain and RFID or sensors, real-time alerts could be created in case actors try to tamper data. Indeed, as users in the supply chain will check and inspect the information of the product when they receive it from upstream participants and transfer it to downstream participants, they can identify if the data found on the product's digital profile match the product's original attribute. In case both do not match, an alarm can be raised in the system in order to find where it went wrong and who is responsible.

Secondly, the adoption and implementation of blockchain technology can also guarantee a more secure and trust-based environment. By the intermediary of smart contracts, the system can automatically enforce participants-agreed rules and process steps which can facilitate, verify and execute terms of the agreement (Leong et al., 2018). This can ensure safe payments to sellers or authorized shipments for example (Salah et al, 2019).

III. New business models and sustainable product differentiation

While all actors can add information regarding the product on the distributed ledger, companies can input traceability information while keeping other important proprietary or business-competitive information hidden. Consumers could identify and examine the product's movement along every step in the supply chain from farm to fork. (Subramanian et al, 2020)

According to Lucena et al (2018), using blockchain-based business networks, could lead to an added valuation of around 15% for GM-free soy in the scope of a grain export business network in Brazil. By providing information about the product provenance, companies can enhance their overall brand image. Consumers get more confidence for the quality, and societal and environmental impacts, playing a key role in their purchasing decision process. A clear record of product history will improve buyer confidence that goods purchased are from ethical sources (Subramanian et al., 2020). With a mobile application, consumers could scan a product or QR code for example, to get more information about the origin, producer, quality etc.

All in all, all of these changes, providing increased visibility among all actors, from farmer to consumer, should not be underestimated. The disruptive effect of blockchain could lead to a complete reinvention of the operating model of certain actors along the soy supply chain. Indeed, if consumers start paying more attention to traceability, actors will be incentivized to improve their processes. Transparent and real-time insights into product movements could create a more responsible and sustainable approach for the soy value chain.

Section 6. Emerging challenges of using blockchain in the soy supply chain

The soy supply chain worldwide is multi-actor based and distributed, with numerous actors involved such as farmers, shipping companies, retailers, and distributors. While blockchain technology gains popularity among literature, various challenges need to be considered when thinking about the implementation. The biggest challenges includes the coordination among all actors, which will be introduced in the next section.

I. Coordination among all actors

The vertical integration of blockchain requires a lot of coordination among all actors. Not only in terms of (1) infrastructure but also in terms of (2) data sharing and (3) design decisions.

(1) The access to infrastructure across all actors along the supply chain is probably one of the biggest challenges of blockchain. Tools, machinery, electronic devices and all enabling technologies required to pilot a blockchain solution must be available to the required parties. This can be difficult for certain actors, especially at a low level in the supply chain, farmers may neither have the resources nor the technology or knowledge to integrate their data into a blockchain. Reaching a significant number of actors at a low level would require a lot of effort. However, since there are established and consistent relationships between soy farmers and soy brokers that amalgamate and harvest beans, brokers could be a more appropriate target to accelerate the introduction of blockchain in the soy supply chain. (Demestichas et al., 2020) Multiple startups including 1000 EcoFarms, have already been developing softwares to make blockchain easier to use for smallholders or other actors across the value chain (Kamilaris et al, 2019)

(2) A second challenge in terms of coordination is data sharing. Aligning all actors to a set of standard data and formats in order to share data in a global network is complex. Actors need to agree what data should be shared and accessed by everyone and what should be private. To make it easier, it is also important that participants agree on a small set of core data. This minimum viable data set will enable an easier implementation and coordination across the supply chain. Another challenge alongside this data sharing is accuracy. Blockchain may be immutable ledgers, however, the accuracy of data that are inserted by the sensors or persons cannot be guaranteed. If either a sensor malfunctions, or a person is malicious, the information contained on the blockchain will not be correct. Moreover, accurate data regarding environmental issues can also be hard to retrieve.

(3) A last challenge is related to the design decisions of today's blockchains. Indeed, because of the high latency of certain blockchains such as the permissionless blockchain, it might take up to some hours until all actors update their ledgers and the smart contracts become publicly accessible. This means that a lack of flexibility could occur, making blockchain alternatives less efficient than the equivalent conventional centralized approach. (Kamilaris et al, 2019)

II. Regulatory and market incentives

Developing regulations and policies related to blockchain is a necessity if used at a larger scale. Current cryptocurrencies are experiencing high daily fluctuations and speculations, resulting in a reduced overall trust of the public while having a negative effect on its reputation. Hence, without controlling authority, blockchain and more especially cryptocurrencies are not trustful enough to be used as a solution in supply chain issues. (Kamilaris et al , 2019) Furthermore, sustainable soy being still a niche product with limited market demand, supporting regulations and incentives could incentivize the adoption of blockchain (Leong et al., 2018).

III. Cost of adoption

The cost of implementation of blockchain is probably one of the biggest challenges. Cost saving being usually the ultimate driver for companies to opt for technology adoption, the capital investment of blockchain is high because of the consensus algorithm used requiring significant computing power to process transactions (Subramamian et al, 2020). Besides the fixed costs related to the entire infrastructure and the implementation along all actors, companies also need to invest money in training for personnel. On the other hand, blockchain reduces reverse logistics costs, recalling costs and improves the planning forecast, decreasing potential losses due to human error (Varriale et al., 2020). A cost-benefit analysis should therefore be further explored as increased traceability for a product would fundamentally influence an organization's competitive position and lead to premium prices.

IV. Technical challenges

The implementation of blockchain also includes various technical challenges: including data collection, immutability, information processing and potential attacks.

(1) First, if blockchain depends on IoT devices to acquire data, they are vulnerable to security and integrity issues. Indeed, if devices get damaged, data collection or checks are not possible. Besides, some quality parameters of food products can be monitored by objective analytical methods such as IoT devices, but not all of them. Indeed, some variables, especially environmental-based ones, are hard to assess and track. Regarding integrity issues, a malicious person could tamper data provided by IoT devices and integrate this on the blockchain. In this case, the physical item does not correspond with the digital flow. False or erroneous information in the system can therefore not be avoided.
(2) Secondly, as said before, blockchain is immutable. If one actor does something by mistake, and this transaction is verified by other nodes, changing or updating data in the blockchain is impossible. Similarly with the use of smart contracts, they are used to take control of the system and automate steps, once deployed in the blockchain it can never be changed (Pranto et al, 2021).
(3) Third, blockchain is a distributed database, and information processing is therefore much slower and efficient than central database. As blockchain is a distributed

database, it is composed of multiple actors who needs to approve every transaction. This large-scale collaboration slows information processing and affects the overall operational efficiency. (Fu et al., 2020)

(4) Last, as discussed above, blockchain faces issues regarding 51% attacks. If some actors manage to master more than 51% of the computing power of the entire network, data can be tampered. (Fu et al., 2020)

V. Environmental impact

As the use of blockchain grows, the potential environmental impact of this should be taken into consideration. According to the International Energy Agency (2017), the electricity used for mining Bitcoin in 2016 was approximately less than $1/40^{th}$ of 1% of global electricity consumption (Roberto Leonardo et al., 2019). Blockchain consumes hundreds of MegaWatts of energy due to its high computing power based on the Proof-of-Work consensus. As all ledgers are decentralized, higher energy is required to maintain security standards. Based on the length and complexity of smart contracts, energy consumption can also reach different levels (Varriale et al., 2020). Besides the high energy consumption, significant amounts of e-waste are also generated, as blockchain requires specialized hardware and software, which become obsolete approximately every year and a half (Roberto Leonardo et al., 2019). On the other hand, blockchain improves sustainable practices such as waste management, or monitoring of carbon emissions. Therefore, the absolute environmental impact of blockchain remains still unclear and a cost-benefit analysis should be further investigated.

Opportunities and potential benefits	**Challenges and barriers**
Traceability and transparency in value chain	Lack of coordination and access to infrastructure
Support for small farmers	Lack of regulations in place
Increased data accuracy	Cost of computing
Consumer awareness	Cost of IoT equipment required
More informed purchasing decisions	Security and integrity issues
Better monitoring of food	Environmental impact
Avoiding food recalls and scandals	Limited education and trainings

Table 3 - Potential benefits and existing barriers for the use of blockchain in the soy supply chain

Section 7. Conclusion

To sum up, this chapter demonstrates how blockchain technology could improve the traceability in the soy supply chain. By offering real-time data about tracked products and integrating information in a secure and immutable manner, blockchain is able to create a smarter and more secure supply chain. Yet, many challenges including the cost of adoption, technical challenges, or regulatory policies remain to incentivize its wider adoption among all actors. Overall, blockchain produces both sustainable and unsustainable practices. Current works are still unable to provide a clear measure of blockchain's impact, and simulation still needs to be done. The next chapter will review how blockchain can be combined with other emerging technologies to provide an increased automation while enhancing transparency and traceability.

Chapter III. Application of smart contract on Ethereum blockchain (Proposed blockchain model)

Section 1. Methodology

In this section, various related works have been reviewed where blockchain could be used to solve real-life practical problems for food and agricultural supply chains. Blockchain applications have been skyrocketing in the banking, finance and insurance industries, however the literature of blockchain applications in food and agricultural cases just started to pick up steam (Salah et al, 2019). To identify relevant initiatives, a keyword-based search was performed through the UCLouvain Discovery web. The following query was used:

Blockchain AND [Agriculture OR Soybean OR Food OR Supply Chain].

The emphasis was on existing initiatives, research or case studies. Based on this, 18 papers were identified, but only 8 were relevant in terms of using blockchain in the soy supply chain. In the next section, and inspired from the papers, a proposed model using blockchain, smart contracts and IoT devices is reviewed. (see Table 4)

Title	Author, Date
Blockchain-Based Soybean Traceability in Agricultural Supply Chain	Salah et al, 2019
The rise of blockchain technology in agriculture and food supply chains	Kamilaris et al, 2019
Blockchain in Agriculture Traceability Systems: A review	Demestichas et al, 2020
Blockchain and Supply Chain Logistics	Subramanian et al, 2020
Blockchain and smart contract for IoT enabled smart agriculture	Pranto et al, 2021
Blockchain-based traceability in Agri-Food supply chain management: a practical implementation	Caro et al, 2018
Smart Agriculture using Supply Chain Management based on Hyperledger Blockchain	Putri et al., 2020
Blockchain-Based Agri-Food Supply Chain: A Complete Solution	Shahid et al, 2020

Table 4 - Reviewed papers

Section 2. System Overview

Majority of research works in agriculture traceability systems have used public blockchain types in association with Ethereum or Hyperledger (Demestichas et al, 2020). In this system Ethereum blockchain was chosen since itis a programmable platform able to govern business logic. By combining smart contracts and IoT devices, uploaded actions will be recorded and monitored in a smart, reliable and secure way. In this system a permissionless based system with a centralized access control was chosen. Participants could however opt for different parameters such as a public or hybrid blockchain with decentralized control. The characteristics of blockchain depends on the sector and needs of different actors. Smart contracts, blockchain and IoT devices combined are promising technologies towards more traceability in the soy supply chain. With the use of smart contracts, a collection of terms and conditions are established without relying on a third party. By relying on blockchain, our system is able to record transactions with high integrity, reliability and security. By using IoT devices, physical items will be monitored and tracked in real time, this at low power and minimum cost. Caro et al (2019) introduced AgriBlockIot, a blockchain based traceability solution integrating data from IoT along the supply chain. Even though IoT devices have growing concerns regarding security, using blockchain will solve part of these issues (Pranto et al, 2021).

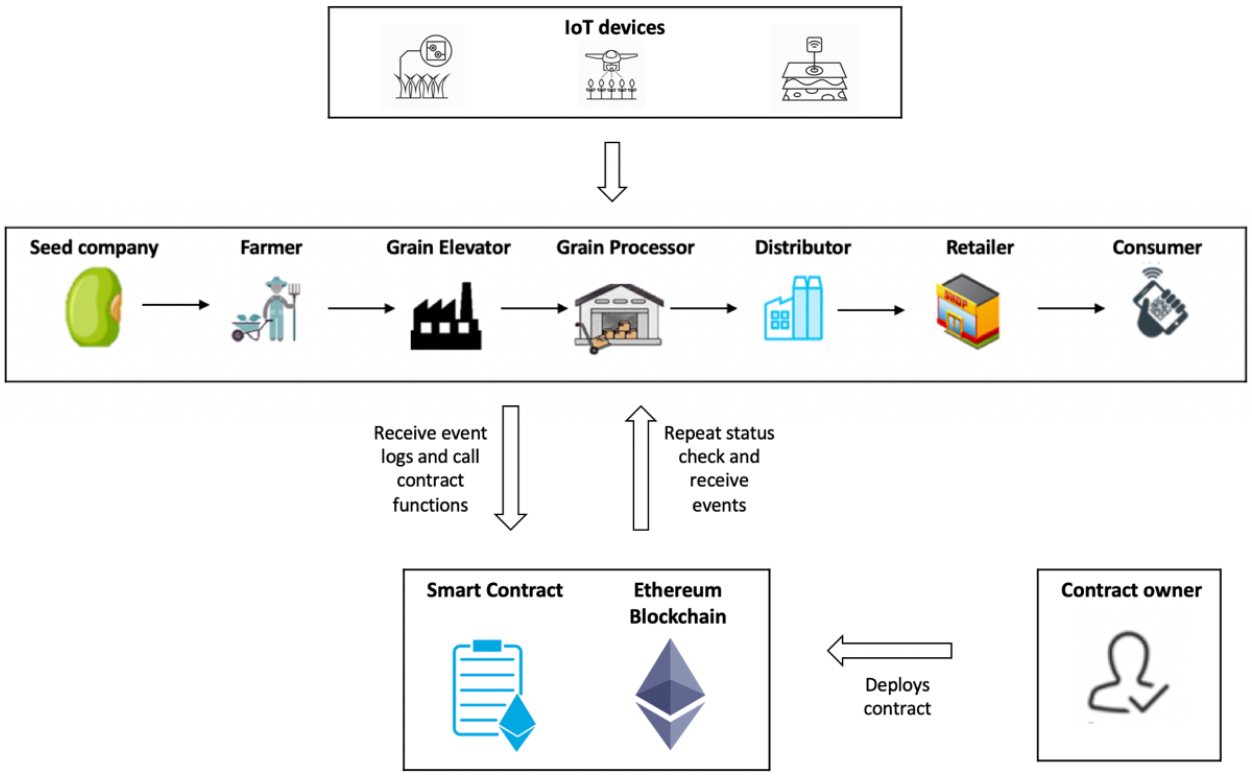


Figure 7 - Overall System Overview

A general overview of the system is shown in Figure 7. As exhibited in Figure 3 the main actors are the seed company, the farmer, the grain elevator, the grain process, the distributor, the retailer and the consumer. The contract owner starts by deploying the contract. Once the contract is deployed, IoT devices are able to get connected and upload the accumulated data on the blockchain. All images, records and data are digitally signed and assigned to a certain actor of the value chain. This means that the actor uploading data is the owner of the action, and is therefore responsible for incorrect or fraudulent records. Smart contracts ensure checks regarding traceability, security and quality and can be programmed in a way to impose fines on an actor if acting dishonestly. In our system, records captured at each stage are validated by all participants in the supply chain, forming a consensus between all actors. After a block is validated, it is added to the blockchain to become a permanent record. Alternatively, Pranto et al (2021) provide a solution for storage capacity constraints on the blockchain by having an intermediary cloud storage Message Queue Telemetry Transport (MQTT). In this system,

general data is stored on the MQTT servers, but confidential records are stored on the blockchain.

Section 3. System Design

I. Actors

The main participants in our proposed model include the seed company, the farmer, the grain elevator, the grain processor, the distributor, retailer and end-user.

- **Contract owner:** The owner of the contract has more power than other actors in the system. In order to solve integrity issues, the owner could act as an external auditor, checking whether rules and regulations are fulfilled or if there is tampered data.
- **Seed company**: For this first stage, the seed company produces the seed and records information such as the details of the seed germination, its chemical composition, viability, quality and dormancy. (Salah et al, 2019)
- **Farmer**: The farmer buys the seed from the seed company and is responsible for the farming. Information about the safety risk from background environment, crop growth, but also farming practices such as planting time, pesticide or fertilizers used are recorded into the system. (Varian, 2020)
- **Grain Elevator**: During this intermediary stage, the grain elevator is in charge of the quality, sustainability and grade of the grain purchased from the farmer. During the storage, important conditions such as temperature, humidity, and duration of storage are written on the blockchain (Salah et al, 2019).
- **Grain Processor**: During this refined process, information about the factory and its equipment, processing methods used, batch numbers etc. are listed in the system. If this stage includes packaging, information about packaging materials and practices are also measured.
- **Distributor:** The distributor, generally a warehouse, records shipping details, trajectories followed, storage conditions, temperature but also time in transit. In this stage equipment is ensured to be maintained properly e.g refrigerated truck.
- **Retailer**: Retailers buy finished goods, usually in batches from the distributors and sell them in open markets directly to the consumers on a small scale. Detailed information

about each food item, its quality and quantity, expiration dates, storage conditions, freshness and time spent on the shelf are included on the blockchain.

- **End-user**: Consumers are the end user; they are essential in the system as they continuously create demand. During this final and consumption stage, the consumer can use a mobile phone connected to the Internet in order to scan a QR code to get all detailed information about the product, from farm to fork.

II. Components: Blockchain, Smart Contract and IoT devices

Ethereum Blockchain

In this example, a permission-based blockchain was chosen based on the Ethereum blockchain. Every actor or participant has to have an Ethereum account, with a unique Ethereum Address (EA) which uniquely identifies the actor. The Ethereum account basically consists of the EA with public and private keys which are used to cryptographically and digitally sign and validate the integrity of the data within each transaction and associate each transaction with a specific EA or account.

Smart Contract

By combining attributes, functions, events, and modifiers (See Part I, Chapter II, Section 4) smart contracts automate processes and thereby remove dependency on third parties. Functions and codes are executed on the smart contract and validated by all mining nodes. Events such as buying or transferring payments can be executed automatically. Participants will also get suitable alerts when violations occur. (Pranto et al, 2021) (Salah et al, 2019) In this example a smart contract based on Ethereum blockchain technology is used as the core apparatus. The contract automates data collection and events, it can self-check for data and compare it with the optimum values. Based on the results, the contract automatically logs events inside the blockchain or triggers an alarm in case both values do not match. Salah et al (2019) provide an example of a smart contract to trace, track and perform transactions in the soybean supply chain. (See Appendix 11)

IoT enabled environment

IoT based technologies is a breakthrough in multiple industries, it is projected that by 2020 50 billion devices would be connected over internet (Nanda Kumar et al., 2021). In the agricultural sector more specifically, IoT devices offer a range of capabilities. From farmers who can monitor their water conservation and soils moisture to end consumers who can track that their products comply with quality standards. IoT offers the possibility to collect data using sensors combined with microphones and cameras connected to the internet. In this section different IoT devices applicable in the soy supply chain will be reviewed.

(1) RFID can provide automatic traceability by enabling a connection between physical objects with their virtual counterparts. RFID could provide consumers with "cold traceability", a concept introduced to trace groups of temperature sensitive products transported in different atmosphere standards (Ruiz-Garcia & Lunadei, 2011). In addition, RFID could provide the beginning of the value chain with more precision in the soy harvesting by increasing efficiencies, productivity and profitability, while minimizing impacts on wildlife and environment. Tags can be attached to products (seeds, fertilizers, pesticides,..) in order to know which products were used and when. RFID tags have security problems as data recorded in the tag could be altered. Combining blockchain and RFID could therefore become a promising alternative for more security and automated operations.

(2) Cameras are another option which can be used to monitor the soybean production. By installing them in the farmers field, they have the ability to automatically shot images and communicate them to the blockchain for storage (Salah et al, 2019) Aerial drones can be used for the analysis of the field, or to assess and monitor the crop health (Ferrag et al., 2020).

(3) Wireless Sensor Networks are an alternative technology to improve crop yield. They are able to decrease potential risks related to the production process while helping farmers to make more informed and accurate decisions. As WSN relies on plenty of low-power sensors in multi-environments, they are able to capture a lot of relevant data regarding the agricultural production. (Ferrag et al., 2020)

Section 3. Implementation and Conclusion

The objective of this chapter is to show the application and opportunity of blockchain combined with IoT devices, and smart contract in the field of soy to ensure more traceability. This system allows consumers to know the origin and history of their soy products via a permissionless based system with a centralized access control. However, participants could opt for different parameters such as a public or hybrid blockchain with decentralized control. The characteristics of blockchain depends on the sector and needs of different actors. To date, blockchain technology still faces some key challenges such as the integrity of data uploaded on the data, or the lack of standardization which hinders its wider adoption among all actors. As a future work, it's interesting to look at addressing some of these challenges and develop an adapted solution.

Chapter IV. Conclusion

To conclude soybeans have long been at the center of the globally consumed agricultural products for many years. In this regard, the governance of the global supply chain is being monitored more closely since a couple of years, in both industry and academia. Even though this commodity has many advantages, the disadvantages linked to its sustainability issues and lack of governance need to be rethought. Although numerous regulations, directives and laws around traceability of agri-food product have been settled (Demestichas et al., 2020), certified soy is still a niche market, and it is complicated to obtain full traceability. Soybeans would nonetheless benefit from more traceability at all stages at the supply chain, from production until end consumption.

This first literature review demonstrates that blockchain technology can advantageously help achieve more traceability by irreversibly and immutably storing data. Many projects and initiatives have proven that blockchain can create a unique level of credibility by building a transparent and more sustainable food production and distribution, integrating the key stakeholders into the supply chain. Adopting and choosing the right characteristics for blockchain for companies is important as they all have different aspects and capabilities. By combining blockchain, smart contracts and IoT devices companies could efficiently perform

business transactions throughout the supply chain. Although this is a promising technology, certain issues and challenges still need to be solved beyond the technical challenges. First and foremost, to reduce barriers of use, governments must enforce policies and regulations to support the adoption of blockchain. Secondly, the economic cost of blockchain still needs to be assessed as the outcomes will likely influence the popularity of the technology. Also, the environmental and sustainability impact of this promising technology still needs to be estimated. Lastly, the adoption of blockchain requires coordination among all actors especially regarding data sharing, infrastructure and design decisions.

To conclude,, although assuring soy traceability with blockchain looks promising, many barriers and challenges still exist, which hinder its large adoption in the soy system. The near future will likely show how these challenges could be removed or addressed by private or governmental effort in order to be adopted by all stakeholders.

Part II. Investigation and Analysis

Introduction

The increasing scrutiny for more traceability is an issue for every actor along the soy supply chain. Multiple sustainable initiatives have emerged in response to the environmental and social impact of soy production, especially regarding deforestation and climate change. However, company commitments to achieve more traceability in their supply chains are not leading to outcomes on the ground. Achieving concerted action by supply chain actors requires therefore consideration of their diverse perspective. In this master thesis, it was thus decided to analyze the current situation and views of different actors along the soy supply chain.

This first part aims at presenting the overall framework used for interviews. The second part will dive into the different interviews hold with multiple actors: ranging from soy certifications, to retailers, to FMCG companies, and end-consumers. From those interviews, the current status quo, motivations and constraints for adopting blockchain will be reviewed. This systemic approach will also help to understand in which directions actors are moving, and how they interact together. The last part will conclude the analysis with a clear recommendation.

Chapter I. The systemic approach

The objective of this chapter is to present the systemic approach chosen for interviews as well as introducing the methodology used for the different actors.

Section 1. Systemic approach

In the soy value chain, every actor has its share of responsibility and all must join forces in order to improve traceability. According to Belleville et al (2019), adopting a systemic approach means *"handling a complex system with a global point of view without focalizing on details and dividing systems into independent subsets." To improve traceability thanks to the*

application of blockchain, it is important to analyze all actors in the system and understand their role in the value chain. Traceability being an increasing issue in today's world, it is essential to take a systemic approach because all actors must work together to improve it.

Section 2. Methodology

Intensive literature research was carried out in order to identify the main actors, issues and constraints. As seen in the literature review, seven actors were identified, from farmer to end-consumer. In order to establish a common thread during the interviews an interview guide was used as base for analysis (See Appendix 12).

Chapter II. Interviews with FMCG companies, Associations, Retailers, Experts and End Consumers

This second chapter will dive into empirical research via extensive qualitative interviews conducted with different actors along the supply chain. From soybeans certifications schemes, to retailers and FMCG companies, to end-consumers, all experts on the subject.

In the following sections, the different methodologies used and a complete summarized analysis of the interviews will be presented. This will allow to have an exhaustive overview of the interviews in order to make the necessary conclusions and recommendations.

Section 1. Interviews with FMCG companies

I. Methodology

First of all, twenty employees from different FMCG companies were contacted by email or via LinkedIn. The approach was done via intensive desktop research, by hunting directly on LinkedIn or via companies' websites. Some of the largest FMCG companies were contacted such as Nestlé, and Alpro (Group Danone) but also some big players in the plant-based industry such as Bjorg and Liquats Vegetals. Among the 20 employees contacted (via email or LinkedIn), two responded positively (Alpro and Nestlé), representing an acceptance rate of 10%. An interview guide with different questions were developed beforehand to support the interviews. (see Appendix 12) Those interviews allowed on the one hand to obtain in-depth

insights on the current situation and practices of soy traceability, on the other hand, to get the interviewees opinion on the feasibility and barriers to the implementation of blockchain.

Company Name	Sector of Activity
Nestlé	Food & Beverages
Alpro	Plant-based products

Table 5 - FMCG companies - Sector of activity

II. Data analysis and results

Status Quo towards traceability

It is interesting to see how both companies have different sustainable commitments towards traceability. Nestlé is a member of the Round Table for Responsible soy, while Alpro is part of the ProTerra certification scheme. Both certifications ensure traceability along the supply chain (described in Part I, Chapter I, Section 6) but according to Mr.. Duquesne, even with excellent initiatives, it could happen that actors in the soy value chain manage to corrupt the standards set. Nestlé is committed to source in a responsible way, but also to promote responsible sourcing. By having an active role as member in the RTRS, companies try to improve responsible soy production on a global level. Additionally, to this initiative, Nestlé does not source from Latin-American countries in order to avoid problems related to child labor, deforestation or other issues in those countries. Nestlé's strategy for its brand Garden Gourmet is to achieve carbon neutrality by 2022, this implies sourcing its raw materials the closest possible from their plants. For its brand Garden Gourmet, Nestlé sources 50% of its soy from Europe and 50% from United states, and by 2022, their goal is to source everything from Europe. Traceability is therefore a consequence of their strategy for their carbon roadmap, as the closest the sourcing, the easiest the monitoring of their transactions. (A. Duquesne, personal communication, 23th of June 2021)

Also, companies like Nestlé are faced with the trade-off between sourcing their commodities in countries like Argentina and supporting small farmers, or sourcing from more developed countries. By sourcing from Latin-American countries, companies are contributing to the externalities related to deforestation or other issues, but providing farmers with a source of income. Whereas when trading with European countries, deforestation is less likely to happen,

but then supporting small farmers is not possible. (A. Duquesne, personal communication, 23th of June 2021)

According to Mr. Basoglu who works at Alpro, traceability is also a high priority in their supply chain. As stated by Mr. Basoglu, plant-based consumers are extremely sensitive to traceability and Alpro is therefore trying to increase transparency and traceability in their system. Currently, the company is starting a trial on one of the sister brands of Alpro, namely on the Provamel plant-based milk. By first developing a questionnaire, the company tried to understand what topics regarding transparency, sustainability and traceability are important for consumers. On top of that, Alpro is in full discussion with other specialized data companies to discuss the opportunity of blockchain. The main drivers behind those implementations are more based on self-sustained actions. On the one hand, Alpro would like to improve its brand image and be more transparent to its consumers. On the other hand, the company got pressure from its competitors (Oatly for example), and therefore wants to maintain its competitive edge.

The role of certifications

It is interesting to question whether blockchain would be an additional tool for traceability with certifications or a replacing system. According to Alpro, certifications allow the consumers to ensure that products are certified in a certain way. Moreover, it brings uniformity in the whole network. Regarding Nestlé's opinion on certifications, according to Mr. Duquesne, certifications have one clear objective: improving the actual situation regarding the soy supply chain. Nestlé being the biggest food and beverage company in the world, it is expected from all stakeholders that they pay attention to sustainability. Being certified is therefore a must have from a consumer perspective, but also from a market's perspective. Both companies therefore believe it's their corporate responsibility to be certified in today's world.

Opportunities of blockchain

Regarding the potential implementation of traceability both companies can see opportunities. For Alpro, blockchain is one of the most recent and most powerful tool, like an online accounting book, storing and approving your data, on top of being able to be checked by any

connected partner. As a plant-based company, Alpro would like to be able to give more precise information to the consumer such as the source of the seeds, the harvesting methods, additional ingredients used or the transport conditions etc. (D. Basoglu, personal communication, 11th of June 2021).

Challenges of blockchain

Regarding potential challenges to the implementation of blockchain, both food companies referred to high implementation costs. In order to compensate those costs, Mr. Basoglu was mentioning an additional premium for products with traceability features, since the quality of the product is improved. The challenge here would be to increase the consumer purchasing frequency as well as incentivizing the consumer to pay attention to traceability. In order to incentivize consumers, Alpro was thinking about a system where consumers would scan the packaging, get points accordingly to the number of packages scanned and when they hit a certain threshold, get a discount on their next purchased product. This would give them an incentive to pay more attention to product provenance, or other features.

Another challenge for Alpro is the constant communication with the organs of the blockchain and the capture of the information on time. Mr. Basoglu was referring to Tony's Chocolonely chocolate traced with blockchain which had some troubles with the update of information, data on the cows or utilization of resources which were not posted in the blockchain for example.

Nestlé had a different perspective regarding this additional price premium. According to Mr. Duquesne, Nestlé will not be able to sell products with higher traceability at higher prices. Nowadays, the company clearly perceives a trend in the share of economy and share of voice of consumers. Indeed, according to Mr. Duquesne, some people have a low share of sales but a big share of voice. Nestlé gave the example of Seaspiracy representing the vegan community. The vegan community has a small share of economy and generates thus little sales for Nestlé, however they have a large share of voice as everyone heard about the documentary. This difference between share of voice and share of economy is the reason why the large mass market will not be willing to pay more for more traceability in their product. Nowadays, only a low share of consumers is willing to pay a higher price for more sustainable products. According to Nestlé, it is more a duty for companies to increase their traceability. It is a market

standard to which companies should comply, but not at consumer cost. Nestlé is already using blockchain for one of its products namely the Mousline potatoes. However, an additional challenge the company perceives for soy is the number of intermediaries between farmers and end consumers, which is much lower in the case of Mousseline. (A. Duquesne, personal communication, 23th of June 2021)

Concrete actions for more traceability

Besides blockchain as a tool for more traceability, Nestlé is involved towards more regenerative agriculture. According to Mr. Duquesne, entering in this regenerative agriculture model will enhance overall traceability in the future. By working closely with farmers, suppliers and communities, positive environmental and social impacts will be generated. By being committed to achieve net zero emissions, the company is making big changes in its operations but also products. Nestlé just launched a new product, Wunda, made from peas which are highly cultivated in Belgium and France. By offering such products which are a 100% regenerative and carbon-neutral, traceability is much higher and easier to implement than for soy products sourced from America. Nestlé therefore mentioned the more feasible possibility of implementing blockchain in those types of products since sourcing is closer (Duquesne, personal communication, June 23rd, 2021). The outcome of the commitment to achieve net zero emissions seems to be promising in terms of sustainability gains in the form of reduced environmental impact as well asbetter monitoring of operations and therefore improved human rights or fair work practices.

Conclusion

To conclude, both companies want to increase their transparency in their supply chain. On the one hand, Alpro is thinking about blockchain in order to improve its transparency by questioning what elements are important for today's consumer and discussing potential implementation with data companies. On the other hand, Nestlé is more rethinking its operations by being committed to net zero emissions in the future. By supporting more regenerative agriculture, and transforming its product portfolio, the company believes traceability will be enhanced via those strategies. Implementing blockchain is more the next step for companies such as Nestlé, once their operations are monitored more closely. Overall,

both companies see traceability as a market standard for the future and understand they are responsible for protecting the world's most important ecosystem.

Section 2. Interviews with Soybean certification schemes

I. Methodology

Besides interviewing FMCG companies, it has been decided to contact Soybean certification schemes as they are playing a big role in the soy supply chain. The soybean certification schemes were interviewed to have their insights on the current traceability system for soy and the potential transition to blockchain. For this part, two of the leading certification schemes for the soy industry have been contacted, namely RTRS and ProTerra. The contacts of these certifications were found via desktop research. Here both certification schemes were contacted and both responded positively (representing an acceptance rate of 100%). For each certification, more specific questions were drawn up according to their expertise and specific certification area. These interviews allowed on the one hand, to get more insights about how actors along the soy supply chain care about traceability and sustainability, and on the other hand, to get their view on the barriers to implement a blockchain-based solution for the soy supply chain.

Below is a table showing the two associations with a description of their certifications.

Company	Sector of Activity
RTRS	Non-profit organization promoting sustainable soy along the value chain. Offering two certifications: - RTRS Standard for soybean production, holistic certifications ensuring overall sustainability. (Zero deforestation, zero conversion soy production,..) RTRS has the strictest criteria among all schemes (Raymakers, 2021). - RTRS Chain of Custody: supply chains of actors need to comply with specific requirements and procedures. (Responsiblesoy.org, n.d)
ProTerra	Non-for-profit organization that imagines a world where all businesses commit to the protection of biodiversity by shifting to sustainable production, preserving natural resources and assuring that workers and local communities are employed with honor and respect. (*ProTerra Certification Protocol V3.0*, 2019) Certification system is composed of two main elements : - The ProTerra Certification Standard.

	- ProTerra Certification Protocol (See Part I, Chapter I, Section 6)

Table 6 - Soy associations interviewed and their sector of activity

II. Data analysis and results

Status Quo towards traceability

It was interesting to question from which actors in the soy system, the willingness for more traceability was coming from. According to Mr. Raymakers, the willingness for more traceability is coming first and foremost from the European Commission itself. Since the election of Ursula von Der Leyen this pressure has even been fostered. Next to the EU commission, corporation and regular NGOs such as WWF and Greenpeace are also pushing a lot toward more legislation. Regarding companies, some of them have intrinsic incentives do opt for more traceability while other care less.

An interesting point regarding soy is the particular way that soy is embedded in the food. As a consequence, consumer-facing firms have been shielded from the externalities of its production and trade when comparing with other food commodities such as chocolate. Consumer awareness towards more traceability is slowly increasing, but this trend is more widely spread in Europe than in other countries. (E. Raymakers, personal communication, June 8, 2021)

Regarding the control of the accuracy of the information, and in order to make sure that companies do comply with the standards, both certifications call upon external auditors and certification bodies that perform certification, audits and training. What is commonly used on top for these checks is the satellite imagery where highly quality data is available. A change in hectare is automatically noticed and alarmed.ProTerra companies which do not comply with the standards during the audits, do not get certified for the following year. (E. Van Maanen, personal communication, July 1, 2021)

The importance of certifications

The two certifications believe it is crucial to have certifications even if more accurate traceability systems would be developed. Not only do these certifications ensure more

traceability but all social, economic and environmental elements are also taken into consideration. (E. Van Maanen, personal communication, July 1, 2021) Certifications are more holistic as they focus on different elements and allow to have more uniformity for consumers.

Defining traceability and the role of regulation

Before implementing regulations, it is also important to define traceability according to Mr. Raymakers. Traceability tells you something about what goes in and what goes out, and what happens in the meantime, but it's of primer importance to know what you want to measure. It's therefore important to define if it is about volumes in terms of non-GMO or certified and non-certified etc. Before giving the tools to actors in the soy value chain and measure things, traceability needs to be defined on a global level. (E. Raymakers, personal communication, June 8, 2021)

Once traceability has been defined on a global level, both organisations believe adaptive legislation are crucial to implement change. Indeed, as companies do their own due diligence, some have more intrinsic drivers to opt for more traceability. Legislation would therefore ensure all soy actors would pay more attention. It's quite common to see that downstream companies provide more effort due to an increasing consumer awareness, whereas traders care less. (E. Van Maanen, personal communication, July 1, 2021)

Lastly, it is a common belief that there needs to be more legislation because certification has not worked. Soy being an embedded commodity, consumer-facing companies have less incentives to opt for sustainable soy and certifications. According to RTRS this is disappointing as looking at the soy agriculture as a whole, some change did happen and in a positive way. In accordance with the literature review, certificated soy is still a niche product and the responsible soy production is still lagging behind when comparing to other commodities such as cacao or palm oil.

Besides the need for legislation and according to Mr. Raymakers, there is also a need for more corporate responsibility. Companies need to understand their impact on the society and environment and therefore put everything in place to prevent any negative impact they may cause including environmental and societal impacts. (E. Raymakers, personal communication, June 8, 2021)

Limits and opportunities for the implementation

Both certifications believe it is possible to implement blockchain in terms of technology. However, Ms. Van Maanen was mentioning different barriers to the implementation of blockchain in the soy supply chain. A first barrier is linked to the economic cost associated with this technology. Companies need to see the turn bound or back profit of implementing such a technology. Moreover, it will not come from upstream companies like traders as they are not willing to share their information. (See Appendix 19) (E. Van Maanen, personal communication, July 1, 2021). A second barrier is due to the nature of the product. As soy batches are made from different aggregation of multiple small farmers, tracking each of the soy products would be complicated. One of the opportunities regarding the implementation of blockchain is related to the fact that only a very small proportion of soy is consumed directly as food for humans. As most of the soy used for this purpose is grown in Europe, implementing traceability is more feasible as the value chain is shorter.

Conclusion

To conclude, certifications have a different role regarding soy when comparing with other food commodities. Soy being embedded in the food system, consumers are less aware of externalities related to its trade and production. Certificated soy is still a niche product and legislation or increased consumer awareness will therefore play a crucial role in the future in order to increase overall sustainability and traceability.

Section 3. Interviews with Retailers (Carrefour Belgium)

I. Methodology

In addition to the interviews with FMCG and certifications, it was also decided to contact retailers on this subject. These contacts have been advised during talks with companies and federations and via Mr. Paque. Five of the biggest retailers were contacted namely Colruyt, Carrefour, Delhaize, Lidl and Aldi via intensive desktop research and LinkedIn. Among the 40 persons contacted, one responded positively (Carrefour), representing an acceptance rate of 2,25%. This type of interview allowed the author, on the one hand to obtain in depth insights on the current use of blockchain and practices, on the other hand, to get the interviewee's opinion on possible future implementation. Here the analogical approach was used, according

to (Küpers, 2012), the analogical reasoning or argumentation by analogy is *defined as " a specific way of thinking, based on the idea that because two or more things are similar in some respects, they are probably also similar in some further respect".* In this case, Carrefour has already implemented blockchain on chicken, and by analogical thinking, this part will use analogies by transferring knowledge from the implementation of chicken used with blockchain to the implementation of soy used with blockchain.

Below is a table with detailed description about the interviewed retailer.

Company	Sector of Activity
Carrefour	Carrefour has over 12 000 stories offering qualitative, and responsible food and non-food products at a fair price. (Carrefour,n.d.)

Table 7 - Retailers information

II. Data analysis and results

Status Quo

Carrefour is a pioneer regarding blockchain and the food industry. It's first application was in 2018 with its chicken from Auvergne Filière Qualité Carrefour. (Carrefour, 2021) With the increasing willingness from consumers for more transparency and quality of their products, Carrefour offered its consumers to scan a QR code on the product label and access transparent information. (R. Fichot, personal communication, June 17th 2021) By scanning the packaging, consumers can find out where the egg was laid, in which hatchery, where it was transferred etc. Carrefour's objective is to apply this technology to all FQC food products by 2022. While Carrefour is focused on this objective on its own brands, it has also worked with Nestlé on giving consumers access to blockchain data for its Mousseline potato puree, allowing them to see it is only made from French potatoes. The use of blockchain to share product information with consumers has resulted in more sales of products and increased consumer trust. (Tapscott & Tapscott, 2016) According to Emmanuel Delerm (Carrefour's blockchain project manager), Carrefour's use of blockchain is building a halo effect (Thomasson, 2019); by increasing consumers' trust with chicken, overall consumers' perception is increasing for other products as well.

Carrefour's strategy to increase traceability for consumer is part of its ActForfood program. The company is committed to make healthy, quality and sustainably produced food accessible to everyone.

In terms of implementation and verification of accuracy of data, Carrefour has external auditors to control the information uploaded on the blockchain. According to Mr. Fichot, the implementation of blockchain allows to have much more information about the chickens than before. In the past, only the origin or product freshness was controlled, whereas now more detailed information is provided.

Challenge to the implementation

The principal challenge associated with blockchain is the lack of awareness of the technology. According to Mr. Fichot, suppliers have a lack of understanding of how it works and consumers are not aware of the technology Carrefour is providing for some of its product. At the beginning of the implementation, Carrefour tracked the number of scans made by consumers and only a small part of consumers where actually using the technology. Regarding the soy application more specifically, it was not in Carrefour's priority to implement blockchain. (R. Fichot, personal communication, 17th of June 2021)

Conclusion

To conclude, the willingness for more traceability is a priority in Carrefour's ambition. With their Act For Food program, the company is committed to improve its food quality throughout the world. Guaranteeing transparency in relation to product traceability is therefore a priority in their program, and this by using blockchain technology. The transition to blockchain for soy products more specifically is different, soy being an embedded product with less consumer-facing value. Overall, implementing more traceability for retailer as Carrefour is a crucial element, with the halo effect, consumers' overall perception is increased when they trust one product. (E. Van Maanen, personal communication, 1st of July 2021)

Section 4. Interviews with end-consumers

I. Methodology

After having interviews with some downstream actors it was also important to take end consumers perspective into account. Indeed, in the last decades consumer concerns for food

safety have significantly increased (Hansstein, 2014), and purchasing habits are likely to change.

II. Data analysis and results

The importance of more traceability

Traceability is playing a key role in consumers purchasing decisions and is a guarantee of safety and quality for consumers. Since 2005 EU traceability and regulations have been introduced and are mandatory. According to Hansstein (2014), studies suggested that among traceability information presented on labels, the indication of origin was the most preferred, however, according to Ms. Frontero, not only origin, but detailed information about the supply chain, environmental and social impacts are also important.

Regarding the willingness to pay for more traceability, this was not a trade-off for Ms. Frontero. Companies should offer this to consumers, and it shouldn't be a premium to have access to responsible food. It should rather be a market standard than a premium information offered by companies. Personally, Ms Frontero was already using the traceability tools companies put at disposal including QR codes for example.

Opportunities of blockchain

Labelling is one of the common current instruments used to convey product information to consumers. However, the space on the label is limited, and may not be able to provide sufficient information to consumers. With the rapid development of new technologies and the IoT devices or Industry 4.0, labels can no longer be the only way to convey product information to consumers and blockchain could be a potential traceability system offering a larger capacity to store more information. As seen for the Carrefour chickens using blockchain, the information provided is more in-depth regarding quality and safety of the product (R. Fichot, personal communication, June 17th 2021). By scanning QR codes consumers can therefore obtain information from retail back to farmers. Additionally, blockchain can ensure more safety by tracing outbreaks. Information such as storage temperature, expiry data, factories location etc. could be stored.

Besides, if blockchain systems for more traceability are developed, it is important to keep in mind that they should be user-friendly, and not requiring too much additional work (Sander et al, 2018 cited by Varian, 2020). Moreover, it is important to distinguish and capture the essence of the information when communicating with consumers (Kendall et al, 2019 cited by Varian, 2020). When consumers are unable to understand the label, the labeling leads to distrust, it is therefore essential to put the essence of the information, not overloading consumers and using less jargon (Varian, 2020).

Section 5. Interviews with experts

I. Methodology

In addition to the interviews with actors along the soy value chain, it was also decided to contact some experts on the subject. One particular expert has been identified, namely Sylvain Quiedeville, a PhD researcher at FiBL Switzerland. In the table below an overview of the company can be found with its description. For the moment our researcher is exploring the potential of blockchain on bio products, similarly to Part II, Chapter II, Section 3 , the analogical approach will be used in this section.

Company	Sector of Activity
FiBL	Research Institute of Organic Agriculture is one of the world leading institutes in the field of organic agriculture. FiBL's strengths are research and innovation developed with farmers and the food industry to facilitate sustainable agricultural practices.

Table 8 - Company information and description

II. Data analysis and results

Opportunities and challenges to the implementation

According to Mr Quiédeville joining a public blockchain like Ethereum should be feasible. However, as blockchain represents a complete shift away from traditional methods of doing things, the longest the supply chain and the more actors involved, the more complicated the implementation. Indeed, all actors should agree on this implementation and should be willing to share their respective information. It is likely that the implementation will depend on actors having the strongest impact on the value chain, most likely upstream participants like retailers

or food companies. While the pressure for more traceability will come from retailers or consumers, the implementation of blockchain will probably come from retailers as they are aware of the technology. It's commonly seen that retailers develop trials with blockchain, in order to increase consumer's trust and purchasing behavior (S. Quiédeville, personal communication, 14th of June 2021).

Furthermore, according to our researcher, blockchain can play a key role in traceability as it ensures that data is not tampered once it is saved, however, fraud could still happen if inaccurate data is entered to the blockchain. In order to solve this challenge, IoT devices could alarm if the entered data are not matching with reality, this by tracking yields and climate conditions for example. (S. Quiédeville, personal communication, 14th of June 2021)

An additional challenge for the implementation of blockchain includes the aggregation of different batches from multiple cooperatives. Even today, some mistakes are made unintentionally or on purpose and it happens that conventional products are mixed with bio products. In order to facilitate this transition toward more traceability, governments could be essential actors as they define production and procurement standards in their respective countries. (S. Quiédeville, personal communication, 14th of June 2021)

Lastly regarding the potential cost of blockchain, according to our expert, changes will improve efficiency and therefore compensate the cost of technology. (S. Quiédeville, personal communication, 14th of June 2021)

Section 6. The role of traders

I. Methodology

Lastly, besides FMCG, retailers, end consumers and experts, it was highly valuable to have traders insights as they play a key role in the soy value chain. For this, around 25 persons were contacted via LinkedIn, unfortunately, none of them responded positively. Among companies contacted we can find big players such as Cargill and L. Dreyfus. This extremely low acceptance rate is not surprising as according to Ms. Van Maanen (Managing Director at ProTerra), traders are less willing to share their information about their business than consumer-facing

companies. Even though it was not possible to obtain interviews with traders, Ms Van Maanen shared the Soy Transparancy Coalition (STC) public report of 2020. The STC is a group of multi-national actors within the soy value chain which aim to support actors to overcome transparency challenges faced within the soy industry. With increasing scrutiny from NGOs and other shareholders regarding transparency, it's important to asses downstream companies such as traders to understand the levels of traceability. A first annual assessment of key traders was therefore drawn to get a more representative view of the soy sector and understand where progress is being made. (Soy Transparency Coalition, 2020) The evaluation focused primary on determining which traders were committed to providing soy in a responsible manner, defining credible objectives to achieve their goals and outperforming their peers in sustainable practices. Based on this report, current relevant findings will be presented in this section, including the status quo and barriers in the implementation of blockchain.

II. Data analysis and results

Status Quo

In contrast with producers, soy crushers or downstream users which are numerous, there are just a handful of traders controlling the flow of the material from their origin country to the final country. In Argentina for example, five companies make up more than 50% of the export trade, among them companies such as Cargill and L. Dreyfus (Storti, 2019).

According to the Soy Transparency Coalition, some key themes were found across different traders surveyed. First regarding the transparency, there was a significant variation in the willingness to share information on their situation and targets. Questions that typically elicited high reluctance to respond was regarding the number of suppliers engaged on sustainability matters or the trader's certification scheme. Those information were not shared for "commercially sensitive" reasons. Secondly, while six traders questioned had their own certification scheme, many other traders cited a lack of demand as a barrier for more certified soy in their supply chain. In accordance with the literature, soy being an embedded product with little consumer value, it becomes clear that it is a niche market with little demand for certified soy. Last, no traders surveyed was engaged to source a 100% RTRS certified soy in

the future due to a lack of market demand, high prices, and low adoption by small to medium size producers for RTRS soy.

Barriers to more traceability

Regarding some barriers for more traceability, here the lack of willingness is coming from the lack of demand for certified soy. As seen during the literature review, certified soy is likely to stay a niche market in the future and the major uptake of certified soy will depend on regulatory and non-regulatory incentives put in place to expand the sustainable soy boom (Czaplicki et al, 2019).

Conclusion

To conclude there is a need for regulation or increasing consumer demand in order to increase traceability on the traders side. Certified soy is one of the ways to have more traceability, but due to a lack of demand from consumers, traders are not willing to make this transition. More engagement by downstream companies with traders should be done in order to trigger discussion for more traceability.

Section 7. The role of small farmers

I. Methodology

Lastly, at the very start of the supply chain, it was valuable to get farmers insights. However, it was difficult to find contacts, as companies or even traders would not share them. This is not surprising as, according to Ms. Frontero, farmers are quite connected to politics or governments in countries like Argentina, and it is sometimes quite sensitive to reach out to them. (See Appendix 18) (E. Frontero, personal communication 25th of June 2021) However, from other interviews and intensive research, it was sometimes possible to get more information, which will therefore be shared in this section.

Barriers to more traceability

Regarding barriers for more traceability a first hurdle was the cost associated with the certifications scheme, especially for small farmers (Soy Transparency Coalition, 2020). Other barriers mentioned to achieve higher traceability was for administrative reasons including the need to register manually the CAR number and the tax ID for the farmer. Besides, as farmers

have no financial incentive to opt for certified soy, traders reported that due to the lack of demand for certified soy, they were unable to pay any premium or reward farmers for certified soy.

Chapter III. Conclusion

In the next section a clear conclusion of the analysis will be made.

Section 1. Conclusion

To conclude the qualitative analysis of this thesis, it was decided to interview different stakeholders: certifications, retailers, end consumers but also experts on the subject in order to have a global vision of the current situation.

First, all actors across the supply chain are trying to improve their traceability systems, however some of them have more intrinsic drivers to set objective and implement concrete actions. At downstream level, traders are less willing to increase transparency mainly due to a lack of demand for certified soy. At upstream level, consumer facing companies have more pressure from end-consumers and traceability is therefore a priority in their supply chains. The halo effect, increasing consumers overall trust and purchasing habits when trusting one specific product is likely to push upstream companies even further regarding overall traceability and sustainability. However, even though consumer awareness is increasing, soy is an embedded product with less consumer facing value than other commodities and resulting in a niche market for the certified and more traceable soy. Nowadays, only a low share of consumers is willing to pay a higher price for more sustainable and traceable products. The demand for certified soy and the rise of sustainable soy will therefore likely depend on regulatory and non-regulatory incentives put in place in the future.

Secondly, regarding certifications, they have one clear goal namely, improving the current situation in the soy industry. Whether those changes are fast and impactful enough is still to assess, but overall, companies and particularly at upstream level, are taking more and more corporate responsibility and improving traceability becomes a market standard for the future.

Lastly, it remains still unclear whether blockchain will be the adopted technology for more traceability, but trials and proactive discussions around more traceability are changing current operations of businesses in the soy value chain. By securing and performing transactions without the need for a third party, blockchain can improve traceability by connecting all actors and irreversibly and immutably storing data. However, even though blockchain seems suitable to be used, some challenges beyond technical issues remain. Particularly regarding the lack of awareness of the technology on the consumer side or the accuracy of the entered data into the system. Moreover, soy being mostly cultivated in Latin American countries, a blockchain implementation remains harder to monitor, as more actors are involved in the value chain. Lastly, both retailers or certifications recognize external auditors are still necessary to monitor the entered data even if blockchain is implemented. Legislation and strong EU policies would be essential in order to ensure more traceability and support early adopters of sustainable soy.

Conclusion

The aim of this thesis was to understand the potential of blockchain to enhance traceability in the entire soy supply chain. By carrying out an intensive literature research combined with qualitative research, it was possible to better understand the current situation in the soy industry regarding traceability.

In the first part of this thesis, an analysis of the soy industry and its need for traceability was highlighted. By describing the need for more traceability at production, trade and consumption stage, blockchain was identified as potential alternative for more traceability in the soy supply chain by offering a perspective for improvements. Lastly, an application of the Ethereum blockchain was proposed, by combining smart contracts to perform business transactions.

In the second part of this thesis, a qualitative analysis was carried out with different stakeholders. All perspectives made it possible to understand better the motivations, actions and constraints towards more traceability and the implementation of blockchain in the soybean supply chain.

Overall, it was concluded that traceability can benefit most actors throughout all stages of the supply chain, especially regarding environmental and socio-economic issues. As soy in the food industry has little consumer value and demand for certified soy is low, increasing regulations combined with growing consumer awareness towards more traceability will likely trigger changes in the way current businesses operate. Whether blockchain will be the adopted technology still needs to be discussed, as it still faces key challenges related to technical, economic and environmental issues. All in all, blockchain is a promising technology in the food industry, and it is worth considering how it could be combined with other technologies such as IoT devices or RFID to contribute to more traceability in the soy supply chain.

Limitations and future research

Several months of intensive reading, research and analysis was carried out to write this thesis. However, even though it has reached its goal to provide an overview of the current situation in the soy industry regarding traceability, some limitations still appear that may lead to future research.

Firstly, as the soy industry englobes many sectors and applications, the author decided to focus mainly on soy used for food products as end purpose. Since food products represent only a small part of the soy industry, it would be interesting to look at other companies/sectors and not only at food and beverage companies as upstream actors in the value chain.

Secondly, as blockchain is still in its early stages (Varriale et al., 2020), measuring environmental or economic impact remains complicated. In this thesis, the research about the different blockchains and their related performance took an end on the 3rd of May 2021. In the future, many current research studies will probably no longer serve as a reasonable reference. As many new blockchain platforms are appearing, a new evaluation of the current mainstream blockchain systems should be assessed when considering blockchain as a solution to increasing traceability for supply chains.

Thirdly, the qualitative research with different stakeholders also led to certain limitations. Indeed, the sample of actors that agreed to be interviewed was quite limited. This could be explained by the current COVID-19 crisis, which made contacts sometimes difficult. Secondly, some stakeholders and especially at downstream level, could not be reached out. Sensitive topics related to the production of soy could explain this (Frontero, personal communication, 23rd of June 2021). Going more in depth at downstream level could therefore be an interesting path to explore. An alternative path to consider could be the “mostlikely-to-happen” scenarios based on a combination of assumptions such as an increased governmental regulation.

To conclude, many directions for future research and progress can be made. The transition towards more traceability still requires a lot of innovation, reflection and actions from all actors in the soy value chain.

Recommendations to actors

To increase traceability in the soy value chain, various recommendations will be presented that could be taken into account by actors in the soy value chain (directly or indirectly related). It is important to keep in mind that the soy value chain involves multiple actors with different market maturities and that these recommendations are based on the author developed expertise based on the literature review and qualitative research done with different stakeholders.

Recommendations for governments

First and foremost, it is important that governments engage not only on the demand side, but also on production side in order to strengthen sustainability and traceability in the soy supply chain.

On the one hand, governments should try to support on the production side in order to avoid the trade-off companies are currently facing between sourcing from Latin-American countries and providing income to small farmers, or sourcing from European countries and not supporting small farmers. This could be done by **supporting the participation and engagement of traders**, or cooperatives in producing countries for example.

On demand side, increasing consumer awareness and **promoting** the demand for **certified soy** could help to achieve more sustainability. According to the Soy Coalition Report (2020), traders are more willing to provide certified soy if consumer demand increases. Early adopters of soy sustainable certification should therefore be rewarded for their efforts (differential VAT for example).

Furthermore, governments could engage discussions and assist the EU Commission to enforce regulatory policies and non-regulatory targets. It is necessary to have an **adapted legislation** with specific time-based objectives to reach in order to increase traceability. There is a need

for a harmonized legislation in the EU in terms of traceability regarding soy products. Specific **plans and targets** to measure and reduce imports from deforestation zones could be adopted.

Recommendations for upstream companies: retailers or FMCG companies

For upstream companies, it is necessary today to fully integrate the traceability issue into the core elements of the business with clear objectives and milestones.

In order to include this issue, it is necessary for companies **to rethink their operations** if not complying with traceability standards. Once their supply chains are fully traceable, a potential blockchain application could be implemented. Moreover, a cost-benefit analysis is necessary in order to assess the back profit of this innovative technology.

Furthermore, it would be a catalyst for companies to **collaborate** more together with other players in the soy value chain in order to have a fully traceable system. Carrefour and Nestlé have already proven this by providing consumers access to product information via blockchain for their Mousline potato product. This first initiative is a proof that industrialists are willing to move and in the good direction.

Also, companies play a key role on the final consumer purchasing behavior. By **educating consumers** and increasing their awareness for more traceability, more informed decisions could be made. Lastly, by adopting an increased transparency and traceability, companies can benefit from the first mover advantage and enhance their overall brand image.

In conclusion, all these steps could enable an increased traceability for soy-based products and reduce negative externalities related to the soy value chain. Transition towards more traceability will be gradual and will take time for actors to adapt.

Bibliography

Accenture Tracing Supply Chain Blockchain-Study-PoV.pdf. (n.d.). Retrieved 16 March 2021, from https://www.accenture.com/_acnmedia/PDF-93/Accenture-Tracing-Supply-Chain-Blockchain-Study-PoV.pdf#zoom=50

Baliga, D. A. (2020). *Understanding Blockchain Consensus Models*. 17.

Beamon, B. M. (1999). Measuring supply chain performance. *International Journal of Operations & Production Management*, *19*(3), 275–292. https://doi.org/10.1108/01443579910249714

Beamon, M. (1999). *Measuring supply chain performance*.

Belleville, P., Galibert, A., & Duru, M. (2019). *Systemic Approach*. Dicoagroecology.

Caro, M. P., Ali, M. S., Vecchio, M., & Giaffreda, R. (2018). Blockchain-based traceability in Agri-Food supply chain management: A practical implementation. *2018 IoT Vertical and Topical Summit on Agriculture - Tuscany (IOT Tuscany)*, 1–4. https://doi.org/10.1109/IOT-TUSCANY.2018.8373021

Certifications – RTRS. (n.d.). Retrieved 5 June 2021, from https://responsiblesoy.org/certificacion?lang=en

Cope, J. (2002, April 8). *What's a Peer-to-Peer (P2P) Network?* Computerworld. https://www.computerworld.com/article/2588287/networking-peer-to-peer-network.html

Czaplicki, S., Bellfield, H., Lafortune, G., Streck, C., & Hermann, B. (2019). *Toward more sustainability in the soy supply chain: How can EU actors support zero- deforestation*

and SDG efforts? https://globalcanopy.org/wp-content/uploads/2020/12/20191209_ClimateFocus_GIZ_SoySupplyChain.pdf

Demestichas, K., Peppes, N., Alexakis, T., & Adamopoulou, E. (2020). Blockchain in Agriculture Traceability Systems: A Review. *Applied Sciences*, *10*(12), 4113. https://doi.org/10.3390/app10124113

Distribution, A. C. &. (n.d.). *Understanding RFID and RFID Operating Ranges*. Retrieved 10 June 2021, from https://blog.acdist.com/understanding-rfid-and-rfid-operating-ranges

EUR-Lex—32003R1830—EN - EUR-Lex. (n.d.). Retrieved 4 June 2021, from https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32003R1830

Fehlenberg, V., Baumann, M., Gasparri, N. I., Piquer-Rodriguez, M., Gavier-Pizarro, G., & Kuemmerle, T. (2017). The role of soybean production as an underlying driver of deforestation in the South American Chaco. *Global Environmental Change*, *45*(Journal Article), 24–34. https://doi.org/10.1016/j.gloenvcha.2017.05.001

Felea, M., & Alb, I. (2013). DEFINING THE CONCEPT OF SUPPLY CHAIN MANAGEMENT AND ITS RELEVANCE TO ROMANIAN ACADEMICS AND PRACTITIONERS. *Amfiteatru Economic*, *33*, 15.

Ferrag, M. A., Shu, L., Yang, X., Derhab, A., & Maglaras, L. (2020). Security and Privacy for Green IoT-Based Agriculture: Review, Blockchain Solutions, and Challenges. *IEEE Access*, *8*(Journal Article), 32031–32053. https://doi.org/10.1109/ACCESS.2020.2973178

FiBL - About us. (n.d.). Retrieved 8 July 2021, from https://www.fibl.org/en/about-us.html

Figorilli, S., Antonucci, F., Costa, C., Pallottino, F., Raso, L., Castiglione, M., Pinci, E., Del Vecchio, D., Colle, G., Proto, A. R., Sperandio, G., & Menesatti, P. (2018). A Blockchain Implementation Prototype for the Electronic Open Source Traceability of Wood along

the Whole Supply Chain. *Sensors (Basel, Switzerland)*, *18*(9), 3133. https://doi.org/10.3390/s18093133

Flora Southey. (2019, June 20). *Nestlé talks challenges in sustainable soy: Complex supply chains and legal deforestation*. Foodnavigator.Com. https://www.foodnavigator.com/Article/2019/06/20/Nestle-talks-challenges-in-sustainable-soy-Complex-supply-chains-and-legal-deforestation

Fu, H., Zhao, C., Cheng, C., & Ma, H. (2020). Blockchain-based agri-food supply chain management: Case study in China. *The International Food and Agribusiness Management Review*, *23*(5), 667–679. https://doi.org/10.22434/IFAMR2019.0152

Genetically Modified Organisms. (2021). European Comission.

Ghozzi, H., Platoni, S., Tillie, P., & Soregaroli, C. (2018). TCE determinants and governance forms in the EU "Non-GMO" soybean supply chain. *Food Policy*, *78*(Journal Article), 68–80. https://doi.org/10.1016/j.foodpol.2018.02.011

Global Market Study on Soy Protein: Increasing Demand for Soy Protein as a Nutritional Supplement to Drive Growth. (2019). *PR Newswire*. http://uclouvain.summon.serialssolutions.com/2.0.0/link/0/eLvHCXMwtV1Nb9NAEF3RXOBWVD7Kl0aVgAMysnftjYPEIW1IKKqCUFpxjCbr3VKJ2iV2kPj3nVk7sdML4cBlFa2frPjtZD07mXkjhJLvw-DOnhDrLIm1dE4u4lj2beginUpD7rvO0CVcnHw2lt9Ggy9jbnOw1kRo5_7rwtMcLT0X0v7D4m9uShP0mUyARjICGncyg1rT35fk2MpnDf7h_wdmBVcGFr7VpRryLsHJ6Rw2GNlrjqVz9mEHxO1o8N10Ld3PEiLcDtTHFtl9HS05A2lCZ_rqR9ffvduzvIkvcEmTCqI2vki4aYPrWsymp_GWgvXp8Ov2ZK2sS7uCUrQ56DesZ36dXZnqo82Di9me2OsPvLt__H1zTFYD7mLcWycnNq_6832xz1_kBm_sEoY1nw_FPZsfiF81l1BzCZ5LKHIgmqCh6QO0TELNJBCTXQhgCQgdJqFlEqoCPJNQM_lIXIw_nZ98DpqOFcElUacDsmqHSmvyqyLjMJYYpmgTI41JDR0dne2rTJnEpItMWUx

DE2JMLpONM6tDlajHopcXuX0qINXZIrL0W1FIh8o4wn5k6Y3g5CAlN9W6Q_GaGZo3vUpp KDmaU17iqiznLeWH4sjjWOsj52SiGpBOzv4OOj2e7ACaTbdATxqQK6olmnnnytutK9jUf9Dj sgRZ5x7PdkY-Fw9ak30hetVyZV-K-yvzs1j9xqv8lbesW-E1dGA

Gollnow, F., Hissa, L. de B. V., Rufin, P., & Lakes, T. (2018). Property-level direct and indirect deforestation for soybean production in the Amazon region of Mato Grosso, Brazil. *Land Use Policy*, *78*(Journal Article), 377–385. https://doi.org/10.1016/j.landusepol.2018.07.010

Guerrero, A. M., Jones, N. A., Ross, H., Virah-Sawmy, M., & Biggs, D. (2021). What influences and inhibits reduction of deforestation in the soy supply chain? A mental model perspective. *Environmental Science & Policy*, *115*, 125–132. https://doi.org/10.1016/j.envsci.2020.10.016

Hansstein, F. V. (2014). *Consumer Knowledge and Attitudes towards Food Traceability: A Comparison between the European Union, China and North America*. 5.

HL_Whitepaper_IntroductiontoHyperledger.pdf. (n.d.). Retrieved 6 April 2021, from https://www.hyperledger.org/wp-content/uploads/2018/07/HL_Whitepaper_IntroductiontoHyperledger.pdf

Home—Welcome at Carrefour | Carrefour Group. (n.d.). Carrefour. Retrieved 13 July 2021, from https://www.carrefour.com/en

INPE. (2018). *Projecto Prodes: Monitoramento da Floresta Amazônica Brasileira por Satélite*. Instituto Nacional de Pesquisas Espaciais (INPE). http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes

Introduction to Hyperledger. (2018). https://www.hyperledger.org/wp-content/uploads/2018/07/HL_Whitepaper_IntroductiontoHyperledger.pdf

ISO 22005:2007(en), Traceability in the feed and food chain—General principles and basic requirements for system design and implementation. (2021). https://www.iso.org/obp/ui/fr/#iso:std:iso:22005:ed-1:v1:en

Jia, F., Peng, S., Green, J., Koh, L., & Chen, X. (2020). Soybean supply chain management and sustainability: A systematic literature review. *Journal of Cleaner Production*, *255*(Journal Article), 120254. https://doi.org/10.1016/j.jclepro.2020.120254

Jituri, V. V. (2020). RADIO FREQUENCY IDENTIFICATION (RFID) AND EASE OF LIFE. *International Journal of Research -GRANTHAALAYAH*, *8*(8), 49–55. https://doi.org/10.29121/granthaalayah.v8.i8.2020.811

Kamilaris, A., Fonts, A., & Prenafeta-Boldú, F. X. (2019). The rise of blockchain technology in agriculture and food supply chains. *Trends in Food Science & Technology*, *91*, 640–652. https://doi.org/10.1016/j.tifs.2019.07.034

KPMG. (2013). *Sustainable Insight: A roadmap to responsible soy*. 23.

Kumar, V. (2018). The Role of RFID in Agro-Food Sector. *Agricultural Research & Technology: Open Access Journal*, *14*(4). https://doi.org/10.19080/ARTOAJ.2018.14.555924

Küpers, W. (2012). Analogical Reasoning. In N. M. Seel (Ed.), *Encyclopedia of the Sciences of Learning* (pp. 222–225). Springer US. https://doi.org/10.1007/978-1-4419-1428-6_788

Kupers, W. (2012). Analogical Reasoning. In *Encyclopedia of the Sciences of Learning.* Springer, Boston, MA.

Leong, C., Viskin, T., & Stewart, R. (2018). Tracing Supply Chain, Blockchain Study. *Accenture*.

Lucena, P., Binotto, A., Kim, H., & Da Silva Momo, F. (2018). *A Case Study for Grain Quality Assurance Tracking based on a Blockchain Business Network*.

May, P., Fernanda, M., Muccillo de Barcellos, L., Benicio, M., & Milikan, B. (n.d.). *Forests, land use trends and drivers of deforestation and degradation*. Retrieved 31 January

2021, from http://web.a.ebscohost.com.proxy.bib.ucl.ac.be/ehost/pdfviewer/pdfviewer?vid=2&sid=4a8eed95-039f-45fb-8b39-a38ee4eaf2df%40sessionmgr4007

May, P., Gebara, M. F., Muccillo de Barcellos, L., Rizek, M., & Millikan, B. (2017). *The context of REDD+ in Brazil: Drivers, agents, and institutions – 3rd edition*. https://doi.org/10.17528/cifor/006338

Motta, G., Tekinerdogan, B., & Athanasiadis, I. (2020). Blockchain Applications in the Agri-Food Domain: The First Wave. *Frontiers in Blockchain*, *3*. https://doi.org/10.3389/Blockchain.2020.00006

Nanda Kumar, K., Vijayan Pillai, A., & Badri Narayanan, M. K. (2021). Smart agriculture using IoT. *Materials Today : Proceedings*, *Journal Article*. https://doi.org/10.1016/j.matpr.2021.02.474

New tech on the block: Planning for blockchain in the retail and consumer-packaged goods industries. (n.d.). Retrieved 26 March 2021, from https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/ConsumerIndustrialProducts/deloitte-uk-blockchain-in-retail-and-cpg.pdf

Pranto, T. H., Noman, A. A., Mahmud, A., & Haque, A. B. (2021). Blockchain and smart contract for IoT enabled smart agriculture. *PeerJ. Computer Science*, *7*(Journal Article), e407–e407. https://doi.org/10.7717/peerj-cs.407

ProTerra Certification Protocol V3.0. (2019). ProTerra Foundation.

Putri, A. N., Hariadi, M., & Wibawa, A. D. (2020). Smart Agriculture Using Supply Chain Management Based On Hyperledger Blockchain. *IOP Conference Series. Earth and Environmental Science*, *466*(1), 12007. https://doi.org/10.1088/1755-1315/466/1/012007

Raikwar, M., Gligoroski, D., & Kralevska, K. (2019). SoK of Used Cryptography in Blockchain. *IEEE Access*, *7*, 148550–148575. https://doi.org/10.1109/ACCESS.2019.2946983

Recognition of the 'RTRS EU RED' voluntary scheme for demonstrating compliance with the sustainability criteria. (n.d.). European Commission. Retrieved 9 August 2021, from https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/1490-Recognition-of-the-RTRS-EU-RED-voluntary-scheme-for-demonstrating-compliance-with-the-sustainability-criteria_fr

Ren, Y., Liu, Y., Ji, S., Sangaiah, A. K., & Wang, J. (2018). Incentive Mechanism of Data Storage Based on Blockchain for Wireless Sensor Networks. *Mobile Information Systems*, *2018*(Journal Article), 1–10. https://doi.org/10.1155/2018/6874158

ResearchAndMarkets.com Offers Report: Global Soy Protein Ingredients Market. (2019, April 9). *Entertainment Close - Up*. ABI/INFORM Collection. https://search.proquest.com/wire-feeds/researchandmarkets-com-offers-report-global-soy/docview/2205101947/se-2?accountid=12156

Richards, P. D., Myers, R. J., Swinton, S. M., & Walker, R. T. (2012). Exchange rates, soybean supply response, and deforestation in South America. *Global Environmental Change*, *22*(2), 454–462. https://doi.org/10.1016/j.gloenvcha.2012.01.004

Rizzo, G., & Baroni, L. (2018). Soy, Soy Foods and Their Role in Vegetarian Diets. *Nutrients*, *10*(1). https://doi.org/10.3390/nu10010043

Roberto Leonardo, R., Giungato, P., Tarabella, A., Tricase, C., University of Foggia, I., University of Pisa, I., & University of Bari, I. (2019). Blockchain Applications and Sustainability Issues. *Amfiteatru Economic*, *21*(Special 13), 861–870. https://doi.org/10.24818/EA/2019/S13/861

Ruiz-Garcia, L., & Lunadei, L. (2011). The role of RFID in agriculture: Applications, limitations and challenges. *Computers and Electronics in Agriculture*, *79*(1), 42–50. https://doi.org/10.1016/j.compag.2011.08.010

Salah, K., Nizamuddin, N., Jayaraman, R., & Omar, M. (2019). Blockchain-Based Soybean Traceability in Agricultural Supply Chain. *IEEE Access*, *7*, 73295–73305. https://doi.org/10.1109/ACCESS.2019.2918000

Schatsky, D. (2016, June). *Getting Smart About Smart Contracts*. Deloitte United States. https://www2.deloitte.com/us/en/pages/finance/articles/cfo-insights-getting-smart-contracts.html

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*(Journal Article), 69230–69243. https://doi.org/10.1109/ACCESS.2020.2986257

Sitoe, A., Salomão, A., & Wertz-Kanounnikoff, S. (2012). *Forests, land-use trends and drivers of deforestation and forest degradation* (The Context of REDD+ in Mozambique, pp. 1–24). Center for International Forestry Research. https://www.jstor.org/stable/resrep02210.8

Soy transparency Coalition. (n.d.). Retrieved 7 July 2021, from https://soytransparency.org/wp-content/uploads/2021/04/STC-2020-report-public-final.pdf

Soy Transparency Coalition. (2020). soytransparency.org

Soybeans | Union of Concerned Scientists. (2015, October). https://www.ucsusa.org/resources/soybeans

Sspmicro_cadenas_de_valor_soja.pdf. (n.d.). Retrieved 13 July 2021, from https://www.argentina.gob.ar/sites/default/files/sspmicro_cadenas_de_valor_soja.pdf

Storti, L. (2019). *Informes de cadenas de valor*.

Subramanian, N., Chaudhuri, A., & Kayıkcı, Y. (2020). *Blockchain and Supply Chain Logistics: Evolutionary Case Studies*. Springer International Publishing AG. http://uclouvain.summon.serialssolutions.com/2.0.0/link/0/eLvHCXMwtV1LS8NAEF7Ugo-TT3wThHqLZHeTxj14qNUoUgTxcS37CkprW9pG8N87kzQP40E8eNkkm01C9ltmZ2Z3viGEszPPrcmE8zAWXhBbbsLAIIW59oWnTNyKQd_1LcYqdyP2cCXuIkxzkCdFKOv-FXioA-gxkPYP4BcvhQo4hyEAJQwCKGv6cXE5X6GFWaqvX8Hwz3ZnYvZOZDLGim4a9lPZ5w7iYyKRCSNzh97jDks5HpcjB55LzGuShaW3QaFMCkktP1EhvaR9nR1ToS6bnaApImg3qfoVmFfzK-R-xZpnsuIca998s0U5LrKC8ZMlsa2RWF9fdloMOUj9U6Q0fzdvenZhh-7z4yJZDAWIo0b7NurcFO4xxgRoRhSjcfL30owvqfzOGlmT0z7MBTBPzKY_JtNUQ3haJw2LYSMbZMEON8lyHk-wRZolEA4A4WRAOCkQTgHENnmJrp86t-48N4UrkVKeusoEYJoJXxnFQ-5LoTxNuQGVyiipBQ-0UmC5SAYS8Vz5oeVWUBVaahmIdK34DlkajoZ2lzg0ZgIV71YsAt_aWFLpKYksQVaDjI33yEnlP3sfg3QdfdqrdAb194iT_34vvT_f3Nsru37_9yYHZLUcC4dkaTZJ7BFZSfRglHxAvxzPcfoCEdsueQ

Tacket, C., Harris, N., Allard, J., Nolan, C., Nissinen, A., Quan, T., & Cohen, M. (1985). AN OUTBREAK OF YERSINIAENTEROCOLITICA INFECTIONS CAUSED BY CONTAMINATED TOFU (SOYBEAN CURD). *American Journal of Epidemiology*, *121*(5), 705–711. https://doi.org/10.1093/aje/121.5.705

Tapscott, D., & Tapscott, A. (2016). *Blockchain revolution: How the technology behind bitcoin is changing money, business, and the world*. Portfolio/Penguin. http://uclouvain.summon.serialssolutions.com/2.0.0/link/0/eLvHCXMwY2AwNtIz0EUrE5JNjVKAbfFU8xRgi9nIKNkMWAiam1uYpgIb1Gmp4GMLfNyMAl0svdxAS3Vg998lgS-

8yMkvLQN2k_WSUkEC-sAqDHR1KTMDK7AtbwzMjKyOHn4-XqAuF7A6MjIGGmsBPVoHxjfhZuCEm4NUf7gJMrCA9hQIMTClFQkzcMAWm4swiDoB65Ls5AygeoWi1DJoMhBlUHNzDXH20IUbFg8dZYmHbJODus1IjIEF2HtPlWBQSDYwTk41S042sUxJNTFOSUpKMUhLTUtKMTIzTUu0sDSTZJAnYJgUQRXSDFzAehw6MiDDwJoGTLmpskheloOGEQDGh294

The Consumer Goods Forum Helps Make Soy Footprinting Possible: New Soy Ladder Document to Help FMCG Companies Understand Soy Usage Within Their Respective Companies and Proportion of Their Soy Footprint that is at Risk of Causing Deforestation. (2015). *PR Newswire*. http://uclouvain.summon.serialssolutions.com/2.0.0/link/0/eLvHCXMwpV1NS8NAEB38OCgIVlT8quzBa7TZ1CY5Sa1dRRQUheKp7GY3IC3Z2KSC_96ZTVKhBz14ySGBZJLJvMnbzMwDCPh5x1vCBC1VatIel2lkIoMMSFJHY5LoyA9U1W7xIPjzTXwvqFSn37TG1O5uUNJBt7YJrZpf-KFPyRsJ-VX-4ZGOFP1vrUU1VmEduQunUA1HbwsKFsSkkLuEui6ViG2YNFetKkiUU9uY0n2pemIFslW1GNT4L_ta0CIUy2VuZqxfvSQ7sGKyXacvzwZ1Aya7tVYXTNBkBoaZKC_Yo5wY9mK_cKctafWP6qPZk6UYmpo9OBPD18Gd19g0ppnHKabCYvxjUbAPW5JK6LPStdrpA2Bcm44fSRrXo7vchHGiehjP3YjHCh3FD6H96zmP_jh-DJv4tXFJxRY8OIG1cjY3bdjAR2znn_I9O3Wuwu3wevQNvqGv2A

The Food Blockchain. (2021). Carrefour. https://www.carrefour.com/en/group/food-transition/food-blockchain

The ProTerra Network. (n.d.). *ProTerra Foundation*. Retrieved 5 June 2021, from https://www.proterrafoundation.org/the-proterra-network/

Thomasson, E. (2019, June). Carrefour says blockchain tracking boosting sales of some products. *Reuters*. https://www.reuters.com/article/us-carrefour-blockchain-idUSKCN1T42A5

Tillie, P., & Rodriguez-Cerezo, E. (2015). *Markets for non-genetically modified, identity-preserved soybean in the EU.* Publications Office. https://data.europa.eu/doi/10.2791/949110

Torky, M., & Hassanein, A. E. (2020). Integrating blockchain and the internet of things in precision agriculture: Analysis, opportunities, and challenges. *Computers and Electronics in Agriculture*, *178*(Journal Article), 105476. https://doi.org/10.1016/j.compag.2020.105476

Traceability and labelling. (2016, October 17). [Text]. Food Safety - European Commission. https://ec.europa.eu/food/plant/gmo/traceability_labelling_en

Uses of Soybeans. (n.d.). *North Carolina Soybeans*. Retrieved 17 May 2021, from https://ncsoy.org/media-resources/uses-of-soybeans/

Varian Wiryohanjoyo, D. (2020). *Consumer attitudes toward farm-to-fork informatino through blockchain technologies*. Ghent University.

Varriale, V., Cammarano, A., Michelino, F., & Caputo, M. (2020). The Unknown Potential of Blockchain for Sustainable Supply Chains. *Sustainability (Basel, Switzerland)*, *12*(9400), 9400. https://doi.org/10.3390/su12229400

Vasconcelos, A., Guidotti, V., Lathuillière, M., Gardner, T., Löfgren, P., & Pinto, L. F. G. (2019). *Soy and environmental compliance in Brazil: An undervalued risk for global markets*. 8.

Walton, B., & Perkins, B. (2018). *New tech on the block: Planning for blockchain in the retail and consumer-packaged goods industries.*

Wang, R., Ye, K., Meng, T., & Xu, C.-Z. (2020). Performance Evaluation on Blockchain Systems: A Case Study on Ethereum, Fabric, Sawtooth and Fisco-Bcos. In *Services Computing – SCC 2020* (Vol. 1–Book, Section, pp. 120–134). Springer International Publishing. https://doi.org/10.1007/978-3-030-59592-0_8

Wang, T., Zhao, C., Yang, Q., Zhang, S., & Liew, S. C. (2021). Ethna: Analyzing the Underlying Peer-to-Peer Network of the Ethereum Blockchain. *ArXiv:2010.01373 [Cs]*. http://arxiv.org/abs/2010.01373

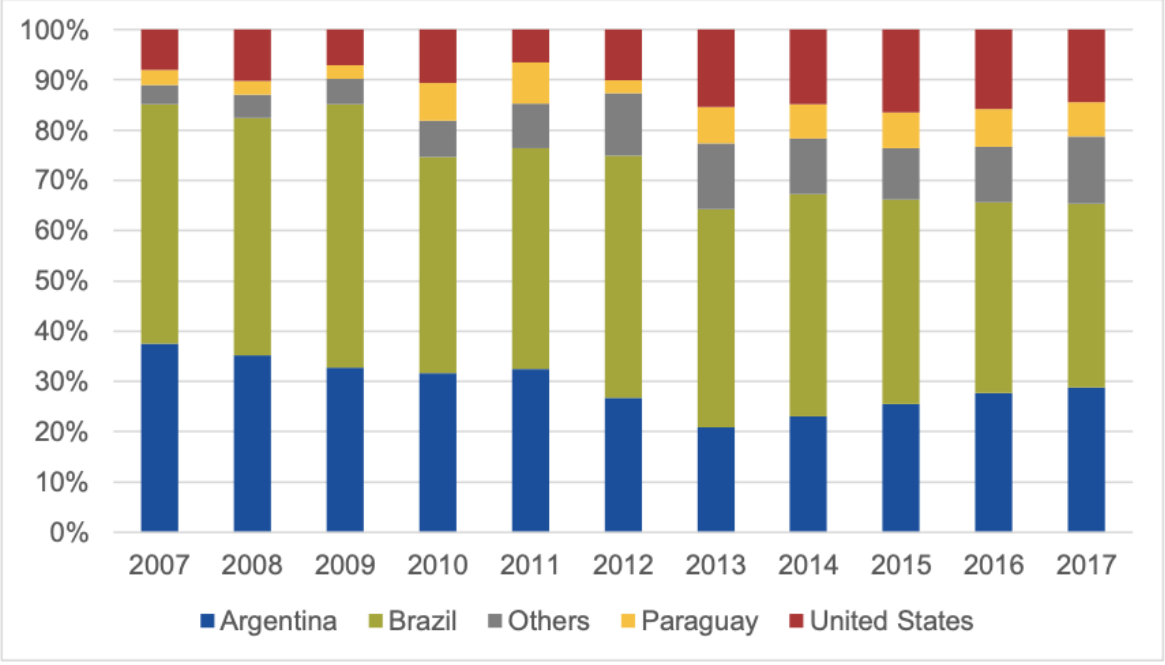
Wattanajantra, A. (2020, August 20). *How blockchain traceability can improve supply chain management*. Sage Advice US. https://www.sage.com/en-us/blog/blockchain-traceability-supply-chain/

William, F. (2020). *Chainlink to provide data for farming insurance startup Arbol*. https://www.coindesk.com/chainlink-to-provide-data-for-farming-insurance-startup-arbol

Xiong, H., Dalhaus, T., Wang, P., & Huang, J. (2020). Blockchain Technology for Agriculture: Applications and Rationale. *Frontiers in Blockchain*, *0*. https://doi.org/10.3389/fbloc.2020.00007

Appendices

Appendix 1 - Share of EU soy imports per major exporter



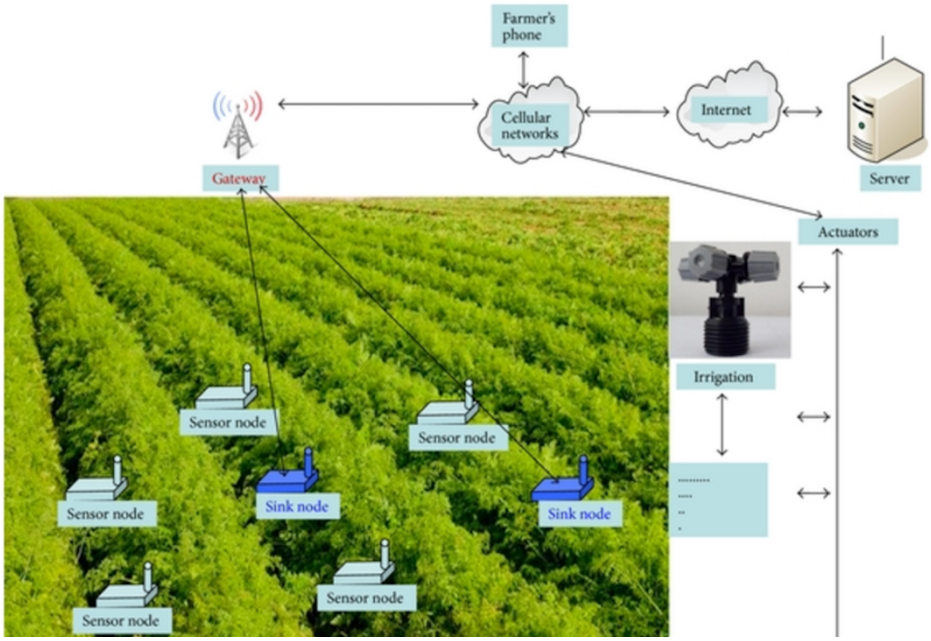
Source: Czaplicki et al., 2019

Appendix 2 - Adoption rate of GM crops across main commodity producers (% of respective area)

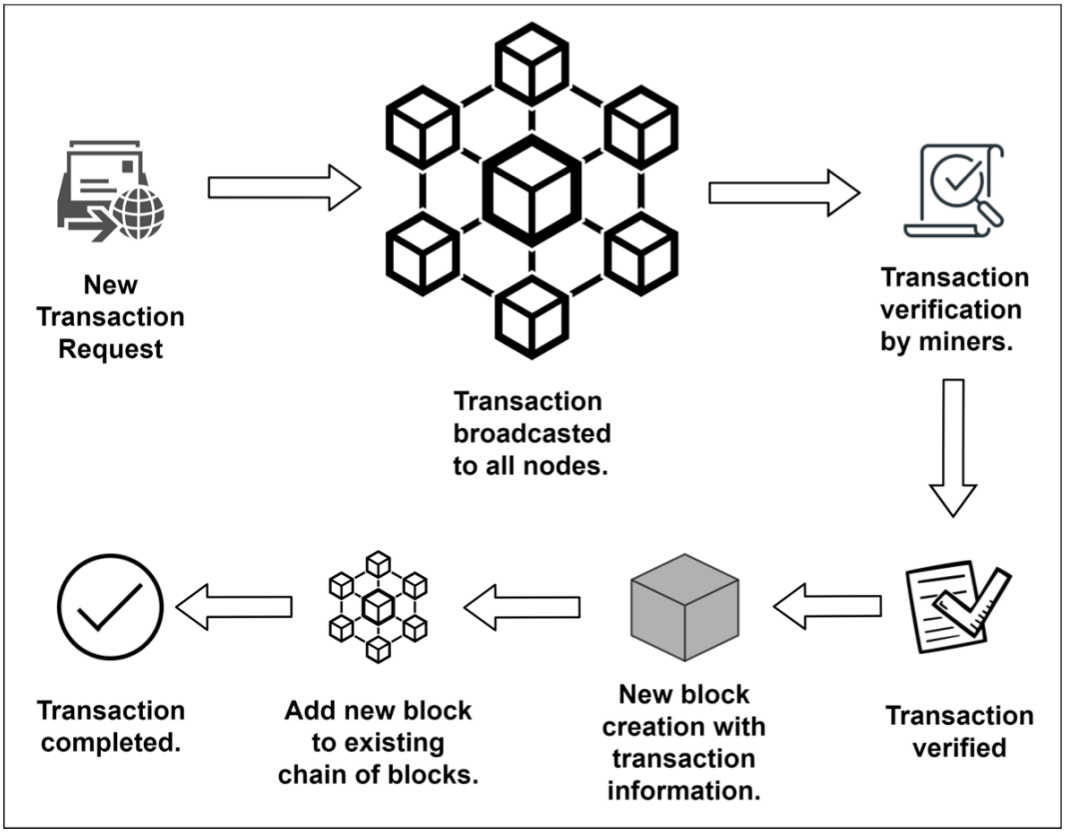
	Soybean	Maize	Cotton	Canola
USA	93	90	90	93
Argentina	100	86*	100	n.c.
Brazil	92	81	47	n.c.
Paraguay	95	50	50	n.c.
Uruguay	100	n.c.	n.c.	n.c.
Canada	46*	58*	n.c.	96
India	n.c.	n.c.	95	n.c.
China	n.c.	n.c.	90	n.c.
Australia	n.c.	n.c.	99	10
European Union	n.c.	1	n.c.	n.c.

Source: Tillie & Rodriguez-Cerezo, 2015

Appendix 3 - Wireless Sensors Networks illustration

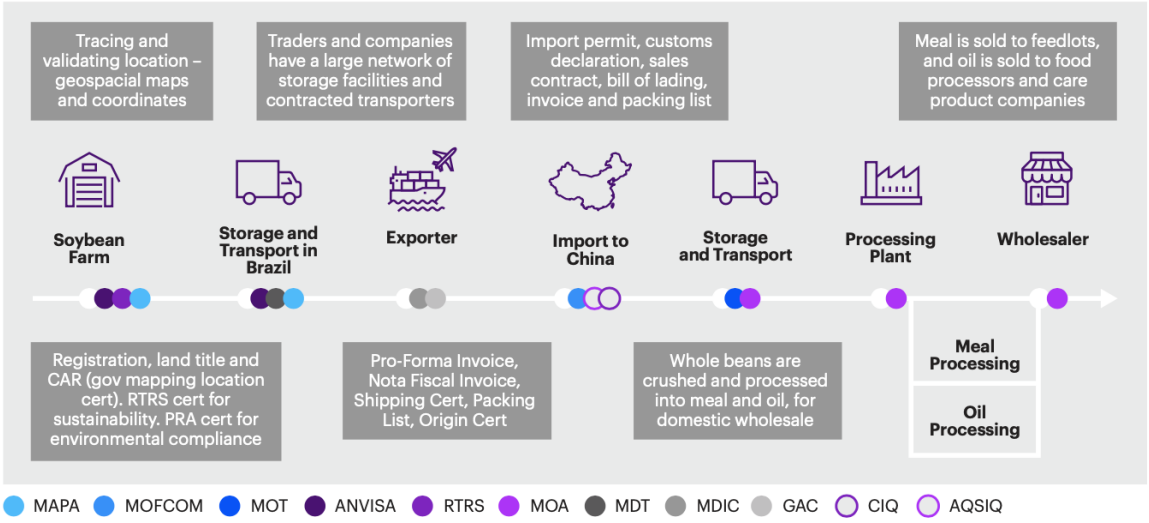


Appendix 4 - Transaction in the blockchain



Source: Pranto et al., 2021

Appendix 5 - Current product flows for Brazilian soy supply chain



Source: Leong et al., 2018

Appendix 6 - Use of different blockchain types and implementation in agriculture traceability systems

Public vs. Private Blockchain	Blockchain Implementation	Research Works
Public	Ethereum	[28–31,33,38,51,52,56,62,63]
	Hyperledger Sawtooth	[54]
	Hyperledger (other than Sawtooth)	[34,49]
	Ethereum or Hyperledger Sawtooth	[43]
	Ethereum or Hyperledger (other than Sawtooth)	[23]
	Not specified	[10,22,24,26,36,39,41,42,44,46,50, 55,59,60,64,65,67,69,70,72,73,78,79]
Private	Ethereum	[51]
	Ethereum or Hyperledger Sawtooth	[23]
	Not specified	[26,32,47,50,66]
Permissioned (Hybrid)	Ethereum	[27,40,48]
	Hyperledger Sawtooth	[37,45,57,58]
	Hyperledger Fabric	[35,53,68]
	Not specified	[25,61,71]

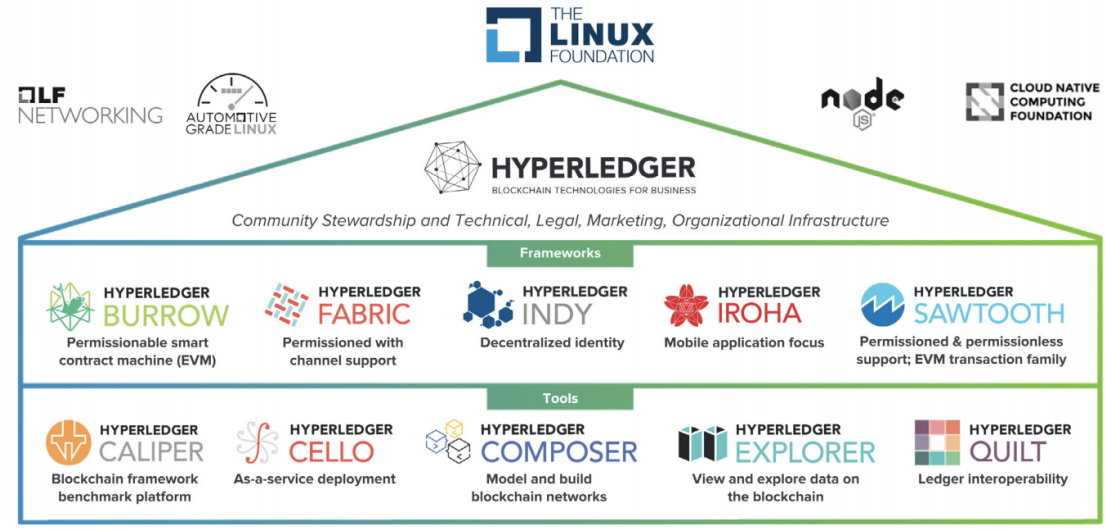
Source: Demestichas et al, 2020

Appendix 7 - Summary of consensus algorithms for blockchain-based solutions

Consensus algorithm	Blockchain-based solutions	Type	Performance (+)	Limitation (-)	How can be adapted for green IoT-based agriculture
Proof-of-Work (PoW)	- Bitcoin [98]	Competition consensus	+ Resistance against DDoS attacks + Resistance against spam attacks	- The computational resources use a lot of energy to valid blocks - - Vulnerable to double-spend attack	- Each access point at agriculture sensors layer are selected as miners, which they calculate the hash values to valid blocks
Proof-of-Stake (PoS)	- Peercoin [99] - Nxt [100]	Competition consensus	+ Avoiding energy expenditure + More costly to attack	- Vulnerable to nothing-at-stake problem.	- Select all IoT nodes in agriculture sensors layer as the validators
Delegated Proof-of-Stake (DPoS)	- BitShares [101] - Steemit [102]	Cooperative consensus	+ Reducing the number of interactions between the nodes + Allows more transactions and faster validation	- Vulnerable to centralization since the number of delegate is limited	- Each access point at agriculture sensors layer is selected as a delegate
Delayed Proof-of-Work (DPoW)	- Komodo [103]	Cooperative consensus	+ Secure and resistant to attacks 51% + Adapted for blockchains that use PoW or PoS	- Vulnerable to notary node attack, eclipse attack, and double-spending attack	- Select all fog nodes in fog computing layer as notary nodes - Select all IoT nodes in agriculture sensors layer as normal nodes
Proof-of-capacity (PoC)	- Burstcoin [104]	Cooperative consensus	+ No dedicated hardware + No constant hard disk drive upgrades are required.	- Vulnerable to malware attacks	- Each fog nodes at fog computing layer are selected as miners
Proof of Stake Velocity (PoSV)	- Reddcoin [105]	Competition consensus	+ Reducing the wastefulness of mining + Requires low computing power or energy	- Vulnerable against attack 51%	- To increase the chances of finding a valid block, an IoT device should have a bigger holding of Reddcoins
Proof-of-Authority (PoA)	- POA.Network [106] - VeChain [107]	Cooperative consensus	+ Provide scalability + Avoiding energy expenditure	- Can used only in private and permissioned blockchains	- Select all fog nodes in fog computing layer as validators
Proof-of-History (PoH)	- Solana [108]	Cooperative consensus	+ Reducing data overhead + Without sharding	- Can used only in private and permissioned blockchains	- Each IoT device at agriculture sensors layer create a historical record
Proof-of-Activity (PoAC)	- Decred [109]	Competition consensus	+ Less energy consumption + Improved network topology	- Vulnerable to double-spend attack	- Each fog node (miner) at fog computing layer uses his hashing power to generate an empty block header - All IoT devices at agriculture sensors layer derive N pseudorandom stakeholders using the hash of the block header
Proof-of-Weight (PoWe)	- Algorand [110]	Competition consensus	+ Prevent Sybil attacks + Achieve scalability	- Reduce the incentive since it's very difficult to be rewarded	- Assigns a weight to each farmer according to the tokens they hold
Proof-of-Burn (PoB)	- Slimcoin [111]	Competition consensus	+ Mining without powerful hardware + More node can become involved in mining	- Only nodes that are willing to burn more money, they have a chance to be miners	- Each fog node at fog computing layer sends coins to a burn address
Proof of Elapsed Time (PoET)	- Hyperledger Sawtooth [112]	Competition consensus	+ Reduced participation costs	- Not appropriate for use in public blockchain networks	- Each IoT device at agriculture sensors layer generates a random wait time and sleeps for a fixed period of time
Proof-of-Importance (PoI)	- NEM [113]	Cooperative consensus	+ Requires no special hardware + Avoiding energy expenditure	- Vulnerable to nothing-at-importance problem	- Each IoT devices at agriculture sensors layer are assigned an importance score
Stellar Consensus protocol (SCP)	- Stellar Consensus [114]	Cooperative consensus	+ Low latency + Flexible trust + Asymptotic security + Decentralized control	- Reduce the incentive since there are no block rewards	- Apply a voting system in agriculture sensors layer to choose quorum and quorum slice among IoT devices and then use quorum intersection to guarantee agreement
Proof-of-Reputation (PoR)	- GoChain [115]	Cooperative consensus	+ Adapted for private and permissioned networks + Avoiding energy expenditure	- Can used only in private and permissioned blockchains	- Select an IoT node as an authoritative node if he has a reputation important enough
Delegated Byzantine Fault Tolerance (dBFT)	- Neo [116]	Competition consensus	+ Less energy consumption + Mining without powerful hardware	- Bookkeepers operate under real identities	- Apply a voting system in agriculture sensors layer to choose bookkeepers and speaker among IoT devices
Practical Byzantine fault tolerance (PBFT)	- Ripple [117] - DeepCoin [118] - Hyperledger Fabric [119] - DeliveryCoin [120] - Stellar [121] - Dispatch [122]	Cooperative consensus	+ Low variance of the reward + Less energy consumption	- The number of messages increases exponentially	- The fog nodes are used to receive requests from IoT devices - The fog nodes create PRE-PREPARE messages to propose to the other replicas the scheduling of the bloc

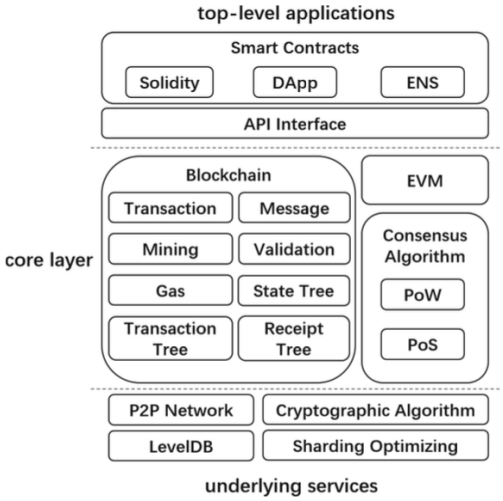
Source: Ferrag et al, 2020

Appendix 8 - The hyperledger structure



Source: Hyperledger.org, 2018

Appendix 9 - Ethereum architecture



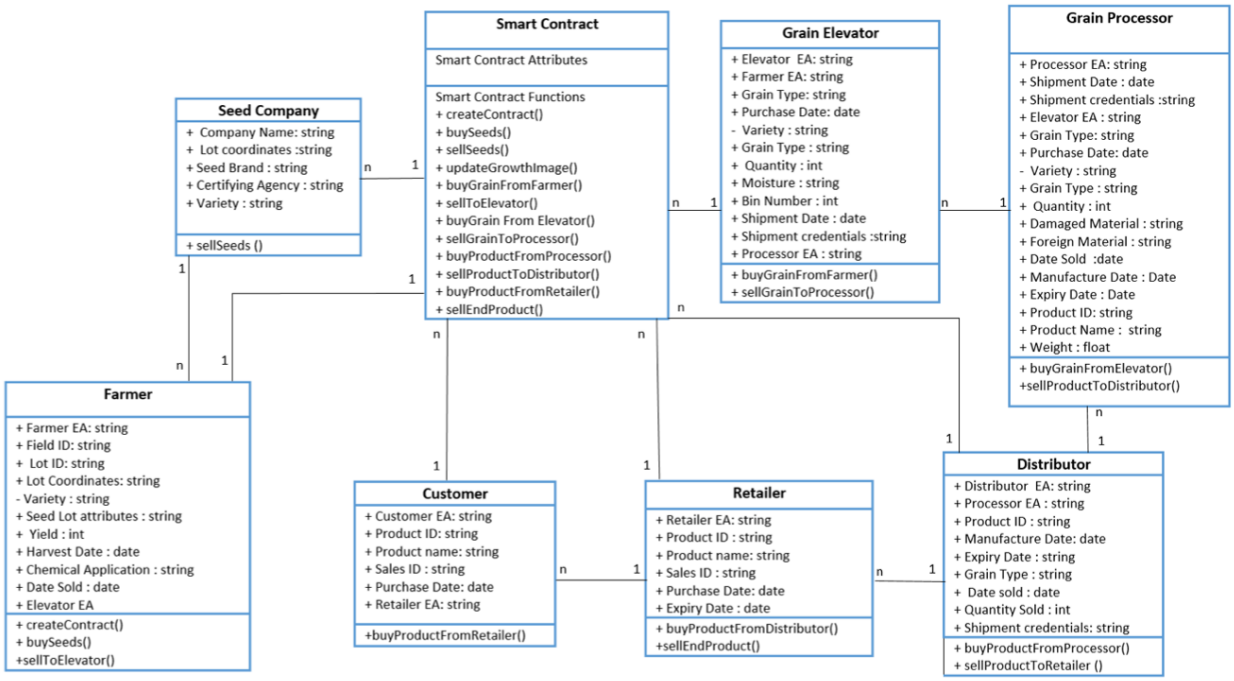
Source: Wang et al,2020

Appendix 10 - Performance of Ethereum and Hyperledger Sawtooth

	latency [seconds]	network tx [bytes]	network rx [bytes]	CPU load [%]
Ethereum	16.55	528'108	682'415	46.78
Sawtooth	0.021	19'303	20'641	6.75

Source: Caro et al, 2018

Appendix 11 - Entity relationship diagram



Source: Salah et al, 2019

Appendix 12 - Interview guide example

Introduction to topic

For the purpose of the research the following question will be addressed: "**From farm to fork: How blockchain could improve traceability in the soy supply chain**? ".

More precisely, this research thesis aims at detailing the *need for traceability in the soy supply chain*. It describes where *traceability systems currently stand today*, and *how it can be improved by leveraging the blockchain technology*. In the last part of this research, a comparative analysis of different actors involved in the supply chain will be done, by assessing the motivations, challenges, constraints or action towards the integration of blockchain in the soy supply chain.

If any information shared during the interview requires confidentiality, a confidentiality agreement can also be signed ahead.

Questions

Status quo

- Could you eventually introduce yourself? What's your experience with the soy industry?
- How do you currently ensure traceability from upstream actors?
- Is traceability a priority in today's soy supply chain?
- What role is regulation currently playing in soy value chain?

Further steps

- What's your opinion on traceability and technology?
- Do you know blockchain (if not give more information) and do you believe this would be a possible solution to increase traceability among actors in the supply chain?
- What would be possible challenges in this implementation?
- Why would you believe actors would aim for more traceability? (Would this come from constrained action (e.g by regulation) or via self-sustain action (based on free market driven activities: better brand image, premium price, ...)?

Appendix 13 - Interview with Evert Raymakers, Europe outreach and engagement manager at RTRS

Margot: Could you introduce yourself a bit more?

Mr Raymakers: I work at RTRS, and I am the first full time representative for Europe. On the one hand, focusing on the market uptake and trying to make sure that existing members stay on board but also trying to capture new members. On the other, on the engagement side, lobbying advocacy work with the EU Commission, NGOs, governments and the engagement with media and social media.

Margot: Are you more reaching the companies, or they reach you?

Mr Raymakers: A lot is reactive, but also proactive. We know in which market we have more potential, the markets where the demand for sustainability is the highest. It's about getting more engagement with the sectors, the brands that are the most relevant for us. Animal feed for example is the biggest sector, then we have biofuels where we engage more. We are getting slowly to engage with the confectionary industry, chocolate, bakery etc. Because in those ingredients, part of is palm oil or soy oil. Then last, synthetics, tire manufacturers for example (Goodyear, became one of our partners) because a lot of the oil from soy are used in the more biodegradable products.

Margot: Two certifications scheme, Chain of custody and Soy Production, Chain of Custody is for traceability right?

Mr Raymakers: Yes, the standard for production is really about sustainability, because that's what we do at farm level, ensuring no deforestation, no conversion,.. Among all schemes existing there we have the strictest criteria's. Then traceability means from farm gate to somewhere here in Europe, so everything that happens in between. In principle you have two different streams you can differentiate: the physical stream and the non-physical stream. The credits or non-physical stream is making sure that a farmer has a certain

quantity of soy produced according to our production standards as sustainable and as certified. So, ensuring those production standards is in both cases, the difference is the traceability. The credit you buy online, you buy soy, and the soy is delivered to you by a trader. It could be that the physical soy you received, example 10 tons, could be that 8 tons comes from certified farms and 2 from uncertified, but it's also possible that 8 tons comes from uncertified farms and 2 tons from certified farms. What you can be sure of is that the 10 tons you buy, has 10 tons of sustainable production, counterbalancing it. Now the Chain of Custody, has its own standards and this requires all the actors in the value chain to be CoC certified. So there you have a much more detailed traceability on the physical flow. That's the key difference between credits as the non-physical, and CoC as physical, then within the CoC you have segregation and mass balance.

Margot: So, you ensure this traceability by ensuring all actors comply with this Chain of Custody right?

Mr Raymakers: From a chain of custody perspective, yes, that's one of the key things. So for example, I'm a big trader company like ADM, they also have their own, crushing plant in Hamburg port. Now that question plant is chain of custody certified. So it means that all of the, the soil volume in their case, it's mostly beans that comes in, comes in through a chain of custody, traceable, supply chain, they crush it, part of it goes for example to biofuels, part of it to the feed industry and all of that can be traced. So that is secured. I have one question for you before we continue Margot, you said that you focus mostly on food companies in your research. Um, can you be more precise about what you mean with food companies?

Margot: Yeah, maybe not food companies, but soy related to human consumption.

Mr Raymakers: Okay. Because that's important that you make a distinction. What I can say and I don't have figures on that, but the big majority of human consumption products produced in Europe actually have a European soy origin.

Margot: Most of the soy used for food products comes from a European source and not from Brazil or Argentina as most of the feed. But you were talking about the European Commission, jumping on this, what role do you believe regulation is playing?

Mr Raymakers: That's hard to answer very precisely, because the requirements are not so much on the traceability so far, but there are much more into due diligence. So can a company or an organization ensure that their entire supply chain, runs according to sustainable criteria. Now, first of all, these sustainable criteria are not all completely defined yet. So I think that's still very much a process that has to happen. What organizations like RTRs are arguing is that we have like, RTRs exist for 15 years, but some similar organization have existed for 30 years already. So we have a long time experience in building up a standard, which is holistic, not only on deforestation or only a GMO, (although that's not part of the standard really) but it is really holistic in the sense that it tackles a great deal of **environmental issues as well as social**.

Mr Raymakers: And we do that **based** on all the **international conventions** that have all been recognized by UN and EU and, and whatever. So it's not that we come up with the things ourselves, we do it based on all the recognized conventions and treaties and declarations. Secondly, there is also an umbrella organization called ICO, which is very much more about the accreditation, of credible certification schemes, because there are many, many certification schemes out there as some of them are run by companies, industries. Some of them have very local, some of them have only one topic that they want to focus on. And there's a huge difference between these organizations. That is something that we very much emphasize. Then based on these requirements, companies are expected to do a due diligence. But that's difficult for a lot of companies. Some of them have more of an intrinsic drive to do it than others; other don't really mind too much. So that's a little bit the danger of a due diligence, even though your legislation at a certain point would be, solid and concrete, which it is not completely yet, but then the process itself may not be entirely sufficient. And what you see in the finance sector and the taxonomy developments is that the finance sector is much into using good certification schemes, at least as one of the important tools to ensure proof of whether the due diligence is properly executed and completely executed. But even that does not say anything about the level of traceability, because those requirements are not entirely set. Traceability tells you something about what goes in and what goes out and what happens in the meantime, but what do you want to measure? Do you want to measure only volumes or exact origin in the sense of non-GMO or certified or non-certified, or, whatever do you want to measure and then separate those

streams in the big flow, or do you want to measure other things that defines what the traceability system you're designing will actually have to measure? You can measure anything if you want, but what exactly do you want to ensure and measure with traceability?

Margot: Where is the increasing traceability willingness coming from? Consumers, EU conventions, companies?

Mr Raymakers: First of all, it is really the European commission itself. I think before Ursula Von Der Leyen , Frans Timmermans has always been a very strong advocate for this. He has really been working hard on it for several years. And then with Ursula now the new president, she has much more ambition than the previous, and that really were the ball started rolling. Secondly, also a lot from corporations who are pushing for more legislation. And then, also very much the NGOs, like the regular NGO, like WWF and Greenpeace. And what is a little bit, disappointing to see and challenging for good standards and certification schemes is that there is a very strong message being given that there needs to be legislation, which we fully support.

But the messages in general is that there needs to be new or good legislation because certification has not worked. And sometimes it's also said that voluntary approaches have not worked. That’s a little bit disappointing because I think if we look at the really credible standards and certification schemes, we have really created quite a big impact. In the case of Palm oil, I think about one fifth of the whole market is actually now incorporated in RSPO, so that's definitely not negligible. In the sense of soy we being the biggest, maybe we talk about 3% of the total, world market, but you have to take into consideration that, maybe half of that comes actually from North America where we are not active. So if you narrow it down to South America and then narrow it down to areas which are at risk, and then you look at the market share that we have, looking at really the tough work that needs to be done, then all of a sudden it would be really a great deal higher. I haven't calculated it, but we, we can easily say that it would be really be a substantial portion because we are close to 5 million tons and Europe uses 30, 35 million tons. So that's definitely not negligible anymore. The whole thing is that we have set always, that we are voluntary standards, which gives clearly away what our handicap is, the fact that it's voluntary.

So only the companies that are willing to support, support. It means also that there is no legislation or regulation from any country that in all these years that we have worked as ever supported us, it was completely up to us. So that's the disappointing part. We don't think it's fair. But besides that emotional argument, we think it's also not correct, because if you look at the numbers they have in fact achieved a lot.

Yeah. So that's why we are saying first, we **need legislation**, we are very much in favor of that. Secondly, we need **corporate responsibility**. That is also very much what we advocate, because otherwise, you know, they push the responsibility in someone else's direction. No, it's the company who needs to be responsible. And in addition to that, the due diligence system should be working in parallel with certification and standards. And then you have a much stronger machine which allows, which allows a second tier, relevant involvement, like for example, from the finance industry, or from technology industry, in the sense of, you know, satellite imaging, etc, these are all second, tools to help to support you with the execution of all the things that you need to do from a system point of view, but they are not systems. They are only tools. That's the key difference.

Margot: Jumping in on this corporate responsibility from companies, do you believe the responsibilities lies in the companies or also in the consumers?

Mr Raymakers: That's a difficult one. That's a little bit of a moral question. I would be very disappointed if consumers would not raise their, sustainability consciousness. I think that we have seen a major change over the last few decades in the sense of sustainability awareness from consumers but that is only the case in a few countries. And I think particularly in Northwest Europeans tend to think that this is the norm, but having lived and work all over, that’s where you start to realize that we are the exception and that I think is something else that still needs to be realized. It’s a need from consumer to drive sustainability but if you live in a country where that is not so much the norm, or if you live in a country or in a situation where your financial and economic, situation, doesn't allow it, then it is a little bit tricky.

So I think consumers play an important role. We live in Western countries that have a lot of money, so yes, we have a responsibility to raise our voice. The other part is that even though

there is a small group of consumers, that's quite aware and conscious in general, there is a lot of unknowing from consumers. For example, why is, deforestation, not per se something that happens in soil industry ? That is placed in the media and in the mindsets of many consumers quite differently and it's simply not correct. It doesn't mean that deforestation, for example, doesn't happened, it happens a lot, but it doesn't have to be necessary. And it doesn't have to be that all the soil that we consume and embed in all the meat products, for example, needs to be unsustainable, or is unsustainable.

As I said, a big portion is already quite sustainable. But I think the main responsibility needs to come from corporate world, but they need the push. So ultimately I think it is the government that needs to set the standards and the criteria and the legislation and that is precisely what's happening now. So personally I'm very happy. I'm only concerned that the final solutions to reach the goals are a little bit insufficient. That is my concern. And that would have a big impact actually, if that happens, but we're not there yet. And I'm happy to say, you know, European commission, they are open, they want to talk. We've also had discussions with them. And that’s the balance that needs to happen in the next few months, because the new proposal will be coming up in September, October.

Margot: Thanks. Um, well, I was also wondering, going on to my main topic, blockchain. First, do you, already heard this in the industry? Would you personally think it's feasible and a future solution to increase traceability and increases sustainability in the soy value chain or what's your opinion on this technology?

Mr Raymakers: No, I'm not, for RTRS, if you want to become a buyer of RTRS soy or even want to be a member, then you need to register, This gives you access to an online platform. It works like a marketplace, and there you can choose, you know, what you want to buy credits, or physical. It is all very direct. It is all registered and it uses the chain point.

What kind of indicators does blockchain include? Because on the production standard, there are many criteria and standard and the producers have to comply with that. We train them on that. We have communications with them on that. And of course there is an assessment

and a monitoring and in the end, there's a third party auditing. So that's the verification process. Those data are then uploaded into an audit report and it tells you, you know, are you compliant or not? And that's where we see possible nonconformities then it goes into the traceability system. And then there it's about following the volume based on which model you choose, whether it's segregation or mass balance or credits, but then it's about following the volume from one actor to the other. That is what it tells you. It does not give you any information on any indicator that has to do with carbon output or satellite imaging, none of that is included. So how does that compare to blockchain?

Margot: Well, in blockchain you would put tags on the soybean, at the farmer level and those tags, can read the temperature, humidity, fertilizers, ... And so actors know exactly what they're buying, but also consumers know where their product has been through.

Mr Raymakers: I'm trying to think about the feasibility of that. As I told you, before 350 million tons of soy, let's look at Brazil alone, last year around 137 million tons. That's a lot of soy. And it's collected very much by big traders and they are active all over as you know, and it comes from many different sources, so it is very, difficult as it gets mixed. Even on a producer level and the producers of soy in south America, usually are very big and still even a big producer in, our view is only supplying a little bit of the total volume. So all of that gets clustered together. We already have a hard time to, to distinguish between, you know, certified and non-certified because in the end, that's all that matters.

My point is that, why would you need to know all these details, which is happening a little bit at the end of the process, where at the beginning of the process, all of these details can be captured in specific criteria. And if you match these criteria as a producer, then the end result, which is, you know, the certificate that piece of paper, in theory, at least tells you and tells everybody who follows in, in the supply and the value chain, how to a consumer, it tells you, " this has been produced and handled according to that same standard". Now if we want to improve the standards, that's great. But what is the use for consumer of knowing how many pesticides are used on a farm level? It, gives most consumers, absolutely, no value.

Margot: Yeah. I see your point. But how can you ensure this certification at farm level, by auditing, I guess you have a lot of, fraud between the certification and non-certificated. How can you make this distinction? You give standards to those farmers, but how do you make sure that you comply with this?

Mr Raymakers:The compliance on the farm level again, that's very much more done on the one hand, before the whole process starts is by having a lot of engagement with the producers, with the farmers, explaining them what the requirements are, giving training. There are also requirements that staff in, in a producer company, needs, you know, they need to allocate the, a person who's really responsible for it, and that person needs to oversee it. So there are, you know, whole process/ procedures of how a company can really make sure and also implement all the sustainability requirements.

So if you ask a company or producer to become sustainable, then you can imagine it requires a, let's say a systemic change in the operations of such a company. It also requires almost a cultural change. That's different in different countries, but it's pretty much, the same everywhere that this is really this change needs to happen. So first of all, you need to really explain a lot why you have certain requirements and then you become more specific about quantifying them. And you also have requirements in the standard with regards to the, the operational changes that you require at a farm level. That means a farmer needs to present a plan with information such as: How are you going to achieve things? What money will you put aside in your operations to achieve it? Who do you appoint in your staff to be the overall responsible person for the, for the sustainability? And how do you ensure that that person includes the rest of the staff? All of these things also need to be covered. They are checked in by auditing. There's also a lot of criteria that have to do, for example, with agrochemicals like pesticides and herbicides and fertilizers. Again all of that, is based on international protocols, like the Stockholm Rotterdam protocol for agrochemicals meaning that, those that are forbidden not allowed, cannot be used at all. And also, we give **training** on how to do good agricultural practices with less agrochemicals, which sometimes means something really as simple as, okay, if it's going to be raining tomorrow than today, no spraying should be done. But also we train on how to reduce the amount of pesticides that are being used. So all of these criteria are set and are given and implemented through training and finally,

and independent accredited certification body (= an auditor) does an inspection at the farm level. Also how to, how to do that. All of that is specified all of that in detail specified according to international norms.

Margot:Okay. I see. Thank you. I guess here, implementation of production would really be a question of coordination among all actors, especially from farm level, as they have low access to technology, whereas downstream companies and food companies is maybe more easily implementable. But it's also about making sure that everyone gets the right price for what he's providing.

Mr Raymakers: Yeah, I see what you mean. That's usually called a premium, at least so far. That that's the most commonly used, price instrument. I definitely will not say that the premium system works perfectly. I think in some cases, farmers receive not enough. We, as an organization cannot influence it. We can influence it by having a dialogue on it, but we cannot dictate it. That is not possible for us. I see the value of making this more transparent, like using blockchain, as you were just explaining the point is that there are not many companies who are willing to do that.

Margot: No, indeed. That's the question it's whereas this willingness for most traceability and transparency coming from is it's from companies which will like self-sustained action (better brand image, premium prices,..) or will they be constrained by regulations?

Mr Raymakers:I think there are two things that are relevant to keep in mind. Soy in general is not really, let's say a consumer facing product or commodity. Most of the soy we consume is in the meat that you buy in a supermarket, or even in the milk. It is so it's called “embedded”. Therefore it has little consumer facing, That’s quite different from chocolate, for example, where everybody thinks, about the “ no child labor, no, this, no, that,..’. It is in the supermarket as a packaged product from, from Côte d’Or or whoever else. That’s really quite a big difference. The second difference is, which company in the value chain has the most consumer facing nature? Here it’s the retailers. So a retailer, a supermarket chain is much more eager to show a lot of detail of what has been done with the product that they receive and that they sell to you as a consumer. Then maybe for example, a trader or a reseller or a feed manufacturer, because most consumers don't even know about. Most

people don’t know big trading companies like Cargill or ADM. So that's quite an important distinction to make between what kind of company, what kind of ambitions and what is the reason for that.

Margot: Exactly. Yeah. Super interesting. Thanks a lot for all these information’s, it was really insightful.

Mr Raymakers: t's quite difficult and it's, it's not an easy topic, but an interesting one. So if you, if you need to ask me a few more questions at a certain point, then feel free to reach out. A lot of the things I've been telling you are important for you to know, and to also understand, for example, the **consumer facing value**, as well as the fact that, the food, for human consumption comes mostly from Europe. It means there are different issues and different let's say traceability requirements that currently are being put on that supply. But if you ask me, I've never been in the Ukraine or in Russia, but all that I see in the media and on TV and whatever it, it does not give me a kind of a guaranteed feeling that there is no deforestation or no land conversion happening in the Ukraine. But that's currently not what everybody is demanding. And a lot of these things happen according to, let's say, what's fashionable, what's trendy, what is the mainstream thinking? And that's where everybody runs into the same direction.

Margot: Yeah. So this raising this consumer awareness, one of the, the solution and issues, I guess, to increasing this transparency and traceability in the social supply chain.

Mr Raymakers:Yes. But, but in a, in a good manner, I think what we need to, there are two ways you can reach your goal. But first you need to be clear on your goal. If consumers want that the products that they are using, whether directly or embedded are going to be sustainable, then we need to come to a more usable definition of what a sustainability. And again, I think we, we have standards that probably would cover 80 or 90% of all of that.

And then the second question is, okay, how do we make sure that future supply chains will occur according to those criteria? How does it done and who is going to execute it? In my view, that's 10 times easier than trying to provide means and tools for consumers and everybody else to measure everything themselves, because it's pretty complex stuff. So

better to say, like you buy a car and we have all agreed. We don't want cars that are polluting more than this or that. Okay. Then at a certain point, that's what you need to know as a consumer.

Margot: So maybe more requirements should also be set by EU commission or other legislation in order to make sure

Mr Raymakers: Indeed.

Margot kay. Yeah. That's an interesting point of view, well, I'll certainly keep this in mind and use all those information. Thank you again for all the information and your time today.

Mr Raymakers: It's okay. I'm happy to be able to help you. I wish you a lot of success in your thesis and by the time you have finished it, if I can receive a copy, I will be very interested in reading it.

Margot: Yeah. I I'll for sure do this. Have a nice day. You too. Bye-bye.

Appendix 14 - Interview with Dogan Basoglu, External student at Alpro

Margot: Before we start I'll introduce myself, I'm 23 years old. I am finishing my master's now in business engineering in Louvain, nearby Brussels. And I'm currently writing my thesis on how the soy supply chain could be enhanced via blockchain and improve traceability more especially. So you work at Alpro, right?

Mr Basoglu: Yes. then I can also introduce myself. So my name is Dogan, and I'm currently at the second year and the last phase of, my Masters of health, food, and innovation management, in Maastricht University. So currently I am working with Suzanne in Global Marketing Acceleration Department. And as a part of my thesis, I investigated whether an application of transparency and traceability would eventually improve the brand image and improve the consumers' willingness to purchase. So based on this, we had questionnaire and we had some people that answered it and we had some very different varying degree of results and it was a really a positive thing. I think it was a really nice thing.

Margot: Seems like I connected with exactly the right person.

Mr Basoglu: Then maybe I starting by your questions on a status quo. So my experience with soy industry actually started with Alpro. So before this I had, of course, bought lots of Alpro products, I had some affinity with the products but not more than that. But with Suzanne, I have learned much more on the brand image and the ways of marketing. Let's just say, because, you know, my background is not really that related. My background was very different because it was on molecular biology and then biomedical sciences and now food innovation, and now marketing. So it was a bit of a journey for me. My life is a bit journey but I think it's the right one. I feel very home thanks to my manager as well. Now going on to, how does Alpro ensures soil traceability and sustainability from downstream actors? So some things that I know is that we have a defined, I do not exactly know the names of the sources, but we have defined sources of the soybeans.

Margot: Yes, I saw Alpro had the ProTerra certification?

Mr Basoglu: Yes we have the certification, but it's when it comes to traceability and transparency we are improving at that point. What I can say there is that Provamel brand, like we did this pilot study for transparency and traceability application for Provomel. So basically Provamel is a sister brand of Alpro, as you know, and we wanted to see whether that improves the image of that brand so that we can implement it to Alpro as well. So basically, what I can say is that traceability, I will connect it to the next question on status quo. Traceability itself is a priority in our point, because traceability and transparency are the things for future. So eventually every single brands including of course our main competitor, as, you know, OAT-LY, they, they are all working on these things and it is only a matter of time. I mean, OAT-LY already has their own application, but specific traceability features are not still there. I check their application, OATLY FARE or something like this.

Margot: And so they have created an app to have more traceability, right?

Mr Basoglu: More traceability, more product information. But the thing is for traceability, it's still insufficient there. There's still lacking things on their app, but it is only a matter of time because OATLY is moving so fast. They’re moving on to the Asian market. They're already

trying to be dominant in the US market. Of course, even though they're growing, they're growing at a very high rates. So it is only a matter of time. So definitely traceability is a priority in our Alpro and Provamel supply chain program.

Margot: And jumping back on your survey where you tried to see if consumers were interested by this increasing traceability and transparency, could you elaborate more on this?

Mr Basoglu: We had some questions. I could just read some questions or I'll ask if I can sent you the questionnaire as well as the findings. But for instance we ask them like: " to what extent they think topic X is important?" So we put them a couple of topics on a table, such as: how is my food produced? Is it important to see the complete journey of my foods? Is it important to buy brands where ingredients come from farmers that use organic practices? How much carbon dioxide is emitted during the production of my food? Etc. Is it important to know that the production process is designed to reduce the waste that is generated? So basically sustainability, transparency, traceability, all of them in a same questionnaire.

Margot: What was the size of the sample?

Mr Basoglu: Including France and Germany, there were 411 people. So 200 approximately from each side.

Margot: Okay quite a lot. If you can share those findings, this would be highly valuable.

Mr Basoglu: Yes I can speak this to my manager and if she approves it, then we can somehow share them.

Margot: I am wondering also if this willingness for more traceability comes from food companies or more regulations and the EU Commission ?

Mr Basoglu: Well that is actually another, status quo question. So basically in 2002 food traceability systems became mandatory in the European Union. In certain sectors there are regulations or requirements for like identification of origin, authenticity, like in the sectors of eggs, fish, beef I think also olive oil. So regarding the plant-based foods and regarding ProvaMel, of course from, from company's perspective, we are as a company transparent to

our consumers. So they know that we are plant-based, they know that we're natural, they have, or they already have that information in the back of their heads, but regarding the traceability systems, we are improving it also from the perspective of improving the brand image as you written here as well.

So basically self-sustaining action, because we know that it is going to be done by the competitors sooner or later. So we also need to do based on market driven activities. In some way driving our customers to buy more of our products. So you can say that it is of course there is a regulation, but as a plant-based brand we are more inclined on improving the brand dimensions, which drives more product sales. Because it will eventually be done by competitors and it will just give us a disadvantage in the end.

Margot: Okay. And what are the solutions you think of when you, when you're talking about increasing traceability do you think of blockchain or do you have completely other solution? And When you say traceability, what do you exactly define with traceability?

Mr Basoglu: Well the definition of traceability is actually basically, like you said, by using the blockchain network from farmers, for instance, the types of fertilizers that are used, the source of the seeds, the harvesting methods, the methodology of processors, the ingredients used during the processing step, like additional ingredients,.. The next step might be just a certification, like types of certification approvals from authorities, and then information on the transport condition, the temperature and the storage conditions. Questions such as how is it stored in the facility and how is it stored in the supermarkets and how should it be stored in the end (at consumer level) will be addresses.

Margot: This you would like to ensure via blockchain, right,

Mr Basoglu: Yes, blockchain is basically the most recent and the most powerful tool. It is like an online accounting book that stores your data, approved data, and it can be checked by any connected partner. So it's, it's actually very easy and everyone can update their information, and it makes tracking things on your behalf, as a company, super simple. It makes peer to peer traits, very simple. So that is the main reason why blockchain is the hot commodity.

Margot: Did you already make some trials or do you have any idea about implementation ?

Mr Basoglu: We have spoken to a couple of companies that are using this technology. There were two companies, two data companies that we have spoken to in terms of implementing blockchain technology. One of them had they had a strange name, like a Chinese type. We are still in communication with those companies to implement such system, we are improving at this point.

Margot: Do you see any potential challenges and pitfalls in this implementation of blockchain?

Mr Basoglu: I think the pitfall can be at the end because these things cost lots of money and thousands of dollars. So I think the main challenge in this implementation is to convince the consumer somehow to purchase more of our products. Because they are going to have to pay additional premium for the product, because the costs are inevitably going to be effected by such an additional system, because it improves the quality of the product in the end. So it has been an ongoing questions to get to customers to purchase more products and how can we give incentives to them. Example: If you scan the pack on our app, you'll get points, and based on those points, after you hit a certain amount of threshold points you will get a discount. It takes certain product or more incentivizing. This is just an example.

Margot: Okay. In order to incentivize your consumer to use this app and to see exactly what's in there and in their product, you would like to incentivize via promotions the more they use the app, right?

Mr Basoglu: Yeah. Definitely. I think that is that is one challenge. Definitely one big challenge to sustain, basically sustain the product as well. Other than that, I think a challenge can be a very generic one, which is being in constant communication within the organs of this blockchain network. Because farmers, processors, plants, and certification from certain authorities, these guys need to be constantly in contact with. And they all have to provide, their information in time. And sometimes we can see that even some companies like Tony's Chocolony, has an integrated blockchain network integrated, they might have some problems regarding some of their farms not following their regulations not posting, not updating their

data on their cows, the utilization of their resources etc. Sometimes that might be a problem as well.

Margot: So you believe consumers would be ready to pay more in order to have more traceability?

Mr Basoglu: Well on the paper, it can always be a deal. It can be an illusion, or it can be a thing that, you know, people can make comments, but do they act upon it? That's the real question, like I could, but will I? That part still needs to be assured, but definitely like you said, at some, someone's got to start it. So at some point we all have to do it. And I think that the world is evolving in there because consumers consider this transparency and traceability as an indicator for safety and quality as you know, because there is an increasing claim for food with well-known origin. So there's definitely going to be that in the future. Either beats due to the regulation or beats due to the market share. Somewhat in some way. It will definitely.

Margot: What do you believe in about the certification? Proterra, for example, I know Alpro is working with them. What's the added value, then of those certification when you implement blockchain, for example?

Mr Basoglu: It assures the customer that it is certified in a way, if they look for it, if they search for it. But also it brings uniformity in the whole network. So whole network would know that we are communicating them and we are working with the cause that we originally aimed to. Because we communicate with certain organs of the network, like farmers, processors, logistics, and so they can also be assured and feel safe in a way that we are working solely on this objective. But of course the added value is to increase the consumer trust, increase the consumer reliance on us. The plant-based consumers are extremely sensitive to these things. So let's say a consumer who buys a chocolate or a biscuits from jumbo they just care comparatively less than the ones who want to purchase a plant-based product. And one of the reasons can be due to the pricing of such plant-based products, as they cost slightly higher than base milk products. So they want to be assured that they are buying THE product, the real, the quality product.

Margot: And Alpro is growing so fast. It's, it's really impressive.

Mr Basoglu: Yeah. It's indeed a really nice thing. I think the plant-based is growing so fast and it is supported by many celebrities, many individuals, companies, etcetera. I think in the next 10 years, it will be much at least as big, maybe even bigger than normal dairy sector.

Margot: Thanks you for your valuable insights today, it was really useful.

Mr Basoglu: Great. That's great that you acquire some knowledge or insight.

Appendix 15 - Interview with Sylvain Quiédeville (PhD) , Researcher at FiBL Switzerland

Margot : Merci pour votre temps, je me présente, j'ai 23 ans, je fais mon master en ingénieur de gestion. Et là j'écrit mon mémoire, qui porte sur la traçabilité du soja. Et comment est-ce qu'on peut augmenter cette traçabilité via l'utilisation de la blockchain.

Mr Quiédeville: Ici, a FiBL on fait beaucoup de choses. On a plusieurs départements socio-économiques, département international, CROP départemental, etc. Donc en fait, on fait vraiment beaucoup choses, presque tout, en particulier sur le bio. Et nous, dans le département en socio-économique et moi en particulier, je travaille sur l'innovation, les systèmes d'innovation, essayer de comprendre les processus, les impacts des innovations, quelles que soient les innovations et aussi l'évaluation de la durabilité. Quels sont les impacts, par exemple, d'innovation sur la durabilité? C'est peut être des impacts de la technologie sur la durabilité ou des impacts des nouvelles pratiques en agriculture, sur la durabilité, donc sur les piliers économiques, sociaux et environnementaux. J'ai commencé à travailler aussi sur Blockchain il y a deux ans. Ce qu'on a essayé de faire, c'est d'explorer le potentiel de pour le bio, plus précisément l'intégrité des chaînes de valeur dans le bio en particulier. Mais on a simplement commencé à regarder la littérature sur ça et on a développé un papier. Mais le papier n'est encore finalisé, on a pas le temps de finaliser, mais on a commencé à travailler sur Blockchain et on essaye de voir ce qu'on peut faire là-dessus. Le département international, il travaille un peu sur l'intégrité des chaînes de valeur , donc, c'est pour ça qu'on a été un peu là-dessus et qu'elles sont.

Margot : Qu'est-ce que vous avez pu déjà interpréter? Vous avez fait aucun essai en pratique pour l'instant ?

Mr Quiédeville: Pour l'instant, on n'a fait aucun essai, mais c'est quelque chose qu'on essaye de regarder.

Margot : Et qu'en penser vous de la faisabilité et l'implémentation?

Mr Quiédeville: Mais après, ça dépend si on développe la blockchain au FiBL, ça, je pense que c'est très compliqué parce qu'il faut avoir les connaissances informatiques. Par contre, utiliser une blockchain existante, comme Ethereum, ouverte ou fermée, ça, c'est sans doute c'est sans doute faisable. Donc, oui, pourquoi pas. Après nous, ce qu'on va faire dans les départements socio-économiques, c'est pas forcément utiliser la blockchain, mais évaluer le potentiel ou, si c'est déjà en place, évaluer les impacts de la blockchain, qu'est-ce que ça apporte en termes de traçabilité, et en termes de durabilité. Plus d'un point de vue recherche que d'un point de vue utilisation.

Margot : Et qu'est-ce que tu avais déjà pu en déduire? Est-ce que vous pensez que oui, c'est faisable au niveau de cette traçabilité?

Mr Quiédeville: Je pense que ça dépend vraiment de la taille de la chaîne de valeur des choses qu'on a. On a vu que plus la chaîne de valeur est grande et longue, plus il est assez compliqué d'impliquer tous les acteurs tout au long de la chaîne de valeur. Donc ça, c'est déjà un challenge super important. Par contre si on est sur des chaînes de valeurs assez courtes, c'est plus facile sans doute d'impliquer les acteurs autour de la table et de dire bon, ok, maintenant, on le fait. Parce que soit il faut un accord de tous les acteurs qui sont impliqués dans la chaîne de valeur, ou alors il faut quelque chose de top-down, un acteur gouvernemental, par exemple, qui dirait ok, maintenant, on va appliquer blockchain et les règles, ça sera ça. Et si vous voulez pas, vous êtes en dehors du marché. Donc soit un acteur gouvernemental ou un acteur de la chaine de valeur.

Margot : D’où vient cette pression selon vous ?

Mr Quiédeville: Je ne suis pas sûr que ça soit le gouvernement, mais je pense que c'est clair qu'il y a une pression des consommateurs, notamment avec les scandales qu'il y a eu dans le passé sur les toxines ou sur du bio qui n'est pas forcément du bio avec des mélanges conventionnels et bio. Ça arrive aussi que ce genre de scandale. Après ça, c'est clair que les consommateurs s’ils achètent du bio, ils veulent du bio. Comme c'est écrit sur l'étiquette, ils veulent que ça soit comme c'est écrit sur l'étiquette. Je pense qu'il y a vraiment cette pression des consommateurs, mais je ne pense pas que ce soient les consommateurs qui vont pousser pour cette technologie, car eux n'ont pas la connaissance détaillée de la technologie blockchain. Je pense que ça va venir des retailers, et c'est ce qu'on voit dans les initiatives existantes. Les retailers commencent à développer la blockchain, ils font des tests en particulier. Il y a quelques applications déjà concrètes,en réalité, les poulets France avec Carrefour. Mais de manière générale, c'est plus encore des tests qu'ils font et je pense que les retailers voit l'intérêt en disant aux consommateurs, vous voyez, on s'occupe de la traçabilité. On peut vous dire quel est l'agriculture qui a produit ce poulet-là, par exemple. Et on peut vous garantir que le poulet que vous avez dans votre assiette, c'est vraiment le poulet qui a été produit ici et que, par exemple, c'est du bio et pas du conventionnel. Et donc, je pense qu'ils vont utiliser cette image-là de fiabilité , essayer de montrer au consommateur que la traçabilité a vraiment été bien suivie et que le produit est sûr. Je pense que c'est ça et ils vont vendre un peu plus cher le produit à la fin et donc ils vont y retrouver leur intérêt. Ou alors ils vont réduire les risques de scandale . C'est un argument commercial.

Après, les gouvernements le font déjà d'essayer de pousser vers la traçabilité parce qu'il y a quand même des normes, en particulier sur ce qui est certifié et après les organismes et les certifications s'occupent de ça. Mais ça ne permet pas d'éliminer toutes les traces et toutes les possibilités de triche/ de fraude. Parce que c'est ça, c'est ça le problème, c'est la fraude. Après la question, c'est ce que blockchain va réellement permettre d'éliminer la fraude. Et c'est la question encore. Selon moi, ça peut diminuer la fraude, potentiellement, mais est-ce que c'est ça l'élimine complètement? Pas sûr. Parce que ça dépend toujours des données

qu'on rentre, donc si au niveau de la ferme, par exemple, y'a un agriculteur qui produit à la fois du bio et du conventionnel, c'est difficile de prouver si les données qui sont rentrés à ce niveau-là sont correctes. C'est très difficile de prouver à ce moment-là si et s'il n'y a pas vraiment une analyse approfondie au lieu de la ferme avec des organismes agréés.
Donc, si au niveau de la ferme il y a un problème, le problème va persister tout au long de la chaine. Donc si en amont y'a des problèmes ils vont se transmettre jusqu'à la fin.

Margot : Les IoT devices, comme RFID etc peuvent intervenir non ?

Mr Quiédeville: Oui on on a commencé a regarder cela également. Puis on peut aussi auditer d'un point de vue externe, voir si la ferme ne produit pas de rendement trop élevé par rapport a la normalité, compte tenus des conditions climatiques et appliqués. Mais ces IoT devices ne garantissent pas à 100%.

Margot : Vous avez analyser cette blockchain pour une commodité en générale ?

Mr Quiédeville: On ne s'est pas intéressée a une filière en particulier. On a fait une revue de littérature générale, et on a regardé ce qui était déjà réaliser sur blockchain, sur la question d'intégrité des chaines de valeurs en générales. On a vu des chaines de valeurs de céréales, de soja au brésil, le poulet également. Ca a l'air réalisable mais plus la chaine est courte plus c'est facile. Ca dépend également de qui a le pouvoir dans la chaine de valeurs pour éventuellement l'imposer, l'avantage c'est que on augmente la traçabilité et garantie, l'inconvénient c'est que les agricultures pourraient se sentir encore plus étranglé par le retailers avec cette blockchain.

Margot : Vous pensez que le fait que les commodités tels que le soja, mais etc peuvent poser problèmes du à leur tailles ?

Mr Quiédeville: Oui en effet, du au différents batches ça peut jouer un rôle. Une vache on peut facilement mettre des senseurs, mais sur un champ de blé c'est plus compliqué a

tracer. Les coopératives qui collectionnent du bio et conventionnels font facilement des mélanges, soit pas erreurs soit intentionnellement. Il faut que une analyse soit faite au départ ;

Margot : Vous pensez pas que ce sont les regulations qui vont mettre la pression ?

Mr Quiédeville: Par rapport a la technologie blockchain non. La traçabilité c'est possible, y'a déjà pas mal au niveau des certifications mais je ne suis pas sur.

Margot : Que pensez-vous de ProTerra, RTRS etc ? Leurs audit sont fiables ?

Mr Quiédeville: Alors je ne connais pas les certifications, mais sur les audits en générale, il y'a toujours un risque que l'audit ne détecte pas les problèmes. Les tricheurs ont toujours une longueurs d'avance et savent comment cacher. Parallèlement les auditeurs ne sont pas toujours bien formé.

Margot : Que pensez-vous des couts de la blockchain ?

Mr Quiédeville: Je ne pense pas que ce soit un inconvénient. Je sais pas si ce sera un avantage mais je pense que les couts de mise en œuvre sont pas trop élevés, dépendant du niveau de complexité bien sûr. Y'a des modifications qui vont être faite et qui vont améliorer l'efficience aussi, donc la diminution des couts compensera le cout de la technologie pour moi. Mais la technologie est assez énergivore oui. Pour moi la seule raison derrière toute cette blockchain in fine c'est améliorer l'image du produit et pouvoir vendre à un prix plus élevé que la compétition ainsi que diminuer les risques vis-à-vis des consommateurs.

Margot : Super on a fait le tour de mes questions et je vois qu'on arrive à la limite de notre temps prévu. Donc mille mercis pour aujourd'hui c'était très intéressant.

Appendix 16 - Interview with Rogan Fichot, Carrefour

Margot: Pour commencer, peut-être que vous pouvez vous présenter et me dire ce que vous faites exactement chez Carrefour ?

M Fichot : Je m'appelle Ronan Fichot. Je m'occupe des achats de toute la volaille pour Carrefour Belgique depuis maintenant quasiment trois ans. Avant ça, j'étais aussi chez Carrefour Belgique, où je m'occupais des produits végétariens. Et avant ça, j'étais chez Carrefour France.

Margot : On dirait que je tombe bien, car vous avez fait un essai avec la blockchain et le poulet si je ne me trompe pas ?

M Fichot : Oui en effet. C'est pas un essai, c'est en place. On a aujourd'hui deux gammes de poulets qui sont sous blockchains chez nous, ici, en Belgique. C'est le poulet d'Auvergne, filière qualité Carrefour et le poulet d'Antan, qui est un poulet belge qui est aussi filière qualité Carrefour. La filière qualité Carrefour, c'est un gage de sérieux, d'accompagnement des producteurs, de juste rémunération et surtout, un cahier des charges assez engageant pour les producteurs. D'un point de vue alimentation, utilisation des antibiotiques, etc. Et effectivement, on a mis en place deux systèmes de blockchain sur ces deux gammes la.

Margot : Et est-ce que vous pouvez expliquer la différence entre les deux blockchain que vous avez implémenté au niveau de ces gammes ?

M Fichot : Je ne suis pas expert en blockchain à proprement parler. C'est pas mon métier car c'est quand même assez technique. Est ce qu'il y a une différence? Non, pas fondamentalement. Il y a une différence dans les produits, dans le sens où il y en a un qui est belge et l'autre qui est français, donc en termes de traçabilité, on va aller sur des sites qui sont différents. Après, d'un point de vue technique, je ne saurais pas forcément te dire s'il y a des grosses différences. Mais c'est de deux choses qui sont assez similaires.

Margot : OK et qu'est-ce que vous tracer exactement avec la blockchain ? Quels types de données les consommateurs savent ils accéder ?

M Fichot : Alors on a un principe de transparence totale d'un point de vue production ,mise en élevage, abattage et stockage (transit par des plateformes jusqu'à l'arrivée en magasin). C'est à dire qu'aujourd'hui, notre consommateur s'il scanne un QR code qu'il a trouvé, par exemple sur un poulet d'Antan filière qualité Carrefour, il va savoir exactement où est ce que l'œuf a été pondu, dans quel couvoir, de quel couvoirs il provient, ou est ce qu'il a été transféré chez l'éleveur, qu'est-ce que le poulet a mangé, d'où la nourriture vient etc. C'est toujours la même chose. C'est le moulin de Hick, près de Wemmel. Puis chez quel éleveurs il a été élevé ,à quel nombre de jours il a été abattu, et dans quelle plateforme ? Il y'en a deux en Belgique. Soit il a transité à Nivelles, soit a Sint Kathlijn Waver et puis jusqu'à l'arrivée en magasin.

Margot : Comment vous capturez l'information ? Est-ce que vous capturez cette information manuellement puis vous la rentrez manuellement dans la machine? Ou est'ce que vous faites usage des IoT devices afin d'intégrer l'information sur la blockchain ?

M Fichot : Bon, alors, c'est là où mes compétences, s'arrêtent un peu. Je les ai mise en place d'un point de vue opérationnel, mais pas technique. Donc, selon moi, je me suis quasiment sûr de ça. C'est notre fournisseur qui s'occupe de tout ça. C'est à dire que lui, il va aller récupérer les poulets chez un éleveur et lors de l'abattage, on va rentrer toutes les données dans le logiciel. Des données tels que : Qui est l'éleveur, quel est le numéro de lot, etc.

Margot : C'est là que je me posais la question est ce que ce n'est pas là que c'est possible de frauder? Ce moment du passage physique au moment digital ? Celui qui rend les données, peut-être, malintentionnés ou simplement par erreur humaine, et rentrer les mauvaises données ?

M Fichot : Potentiellement, effectivement, c'est des choses qui, j'imagine, peuvent arriver. Nous ce qu'on a mis en place pour justement remédier à ce genre de soucis, c'est des contrôles avec des organismes externes, des gens comme Quality Partners, par exemple.

l'Afsca aussi qui peut vérifier des choses et qui viennent auditer notre fournisseur tous les mois.

Margot OK, et l'Afsca et Quality Partners ca fonctionne comment exactement ?

M Fichot : Alors, l'Afsca c'est plus pour la sécurité alimentaire. Quality partnerships, c'est des gens, peut être que tu connais des organismes de contrôle comme Vinçottes, par exemple. C'est un peu des gens qui connaissent le cahier des charges, parce qu'on l'a écrit avec eux, qu'on a validé avec eux et avec le fournisseur et en fonction des différents points du cahier des charges ont validé ou pas, les infos blockchains. C'est à dire que, par exemple, le poulet doit être abattu à minimum cinquante-trois jours si ils s'aperçoivent de 45 jours, ils vont dire non et ils vont bloquer les choses.

Margot OK, d'accord. Et c'est déjà arrivé dans votre blockchain qu'il y ait des contrôles qui ne correspondent pas à la réalité ?

M Fichot : Oui, oui, c'est arrivé. Après nous, ce qu'on fait, c'est qu'on n'accepte pas la marchandise dans ces cas-là, parce qu'on est très exigeant par rapport au respect du cahier des charges et aux fournisseurs de trouver un autre moyen de commercialiser ces poulets en l'occurrence. Après d'où l'intérêt d'avoir des organismes indépendants qui contrôlent ca, des garde-fous on peut en mettre beaucoup, la confiance on peut l'établir, mais en effet si quelqu'un de malintentionné ou même par erreur humaine mets des infos non fiable ça peut arriver. Car oui passer par un organisme indépendant et certifiant c'est une solution, c'est des gens qui viennent sans prévenir de leur passage. Ça change du système d'aujourd'hui car on va beaucoup plus loin. Un organisme certificateur vérifie peut-être l'origine ou la fraicheur du produit, mais la on va plus loin car on va du couvoir jusqu'au magasin. C'est là que ca se différencie de l'Afsca ou autre qui eux vérifie la qualité du produit en tant que tel. Mais c'est également complémentaire ce système de blockchain cela ne veut pas dire que notre fournisseur sur des produits blockchain ne seront pas contrôlés sur d'autres choses. Ce matin par exemple on a refusé des produits qui n'avait pas la même couleur, c'est plus de l'infos que du contrôle, c'est vraiment donner une transparence a notre client.

Margot : Et est-ce que c'est dans la stratégie de Carrefour l'implémenter cette blockchain sur plus de produits et pas uniquement le poulet?

M Fichot : Nous, ici en Belgique, alors je vais parler du périmètre produits frais, on a des blockchains qui sont déjà qui sont déjà efficaces sur différents produits. Alors si on prend l'exemple de la viande, on l'a aussi en porc, on va la voir aussi sur les œufs. En fait une grande partie des produits à marque filière qualité Carrefour a switché en blockchains.
Il me semble aussi que le lait est passé récemment. Donc oui, notre stratégie est claire. C'est pas forcément connu de tout le monde, mais ca s'appelle ActforFood, et ça tourne autour de 12 piliers et certains de ces piliers correspondent tout à fait aux principes de la blockchain. Garantir cette transparence aux consommateurs par example, enlever des substances controversées de nos produits ou nos recettes, garantir quelque chose de durable pour la planète aussi. C'est mieux manger pour demain pour tout le monde. Donc oui, la blockchain elle rentre totalement dans cette stratégie.

Margot : Et cette envie pour plus de traçabilité elle vient d'où ? Pression régulatrice ou plutôt une stratégie pour mieux se positionner etc ?

M Fichot : Non, c'est vraiment quelque chose que Carrefour a mis en place de son propre fait. Justement, pour s'ancrer encore plus et aller au-delà du cadre légal ou la pression que peuvent exercer parfois certaines ONG ou autres. Le but de Carrefour c'était justement de garantir une traçabilité top au niveau de produit pour carrefour ou on est safe niveau cahier des charges, donc là on va au-dessus de tout ça. Les prix ne seront pas affectés par cette décision, le poulet suivi par la blockchain qui est la Rolce Royce du poulet, sera vendu même moins cher qu'un autre. C'est clairement un coût cette blockchain mais ca entre dans notre stratégie et nos budgets sont fait en fonction de ca.

Margot : Quels étaient les plus gros challenges pour cette implémentation ?

M Fichot : alors pour remettre les choses dans leurs contextes, la blockchain je trouve ça génial, malheureusement les consommateurs ne connaissent pas encore vraiment la technologie et quelles infos ils peuvent récupérer. Je ne suis même pas sûr que les gens sachent qu'il faille scanner un QR code, au début de l'implémentation on traçait le nombre de scans, et il était très faible. Les challenges sont également humain, mon fournisseur belge n'était pas spécialement au courant de cette technologie etc., y'a le challenge humain et technique dans la formation des personnes. Après, une fois que les choses sont claires ca roule. Donc challenge humain et consommateurs.

Margot: Donc la faudrait trouver des moyens à booster le consommateur à utiliser cette blockchain?

M Fichot: C'est à lui de faire comme il veut, l'info est la et c'est à titre informatif pour montrer qu'on n'a rien à cacher. S'il n'a pas envie de regarder ses infos c'est son choix. Le challenge c'est la conscientisation des consommateurs, montrer que cela existe, c'est quelque chose qui va plus loin que le cadre légal, qu'on leur offre. Après qui sommes-nous pour les obliger à l'utiliser.

Margot: En implémentant cette blockchain vous ne pensez pas que vous avez vraiment améliorer la qualité de votre produit et fait plus attention a des choses qui arrivaient dans le passée (Ex. Les poulets qui doivent avoir 45j etc) ?

M Fichot: On a toujours fait attention, après il faut des produits pour tout le monde et là c'est un produit qui a un cahier des charges très lourd mais on respecte le cahier des charges de tous nos produits. Mais là c'est nous qui l'avons modifié, et on va encore plus loin avec le poulet Français.

Margot: Carrefour compte implémenter cela sur tous ces produits a long terme ?

M Fichot: Pas sur car ce sont de choses couteuse et longue a mettre en place. Mais sur les produits a marque Filière qualité carrefour ou on prend des engagements clairs, on va essayer de blockchain la plupart.

Margot: dernière question peut-être, les couts qu'est ce qu'ils représentent ? Sont-ils vite offset par d'autres gain comme la vente de plus de volume?

M Fichot: Les couts je ne les connais pas. Je sais qu'ils sont conséquents, après si on va faire des retours sur investissement je ne sais pas. On vend plus de produits Filière carrefour, Est-ce que c'est grâce à la blockchain je ne sais pas. La qualité est meilleure donc quand le consommateur. Pour nous la blockchain c'est un peu du marketing sans vraiment l'être, notre but c'est le max de transparence et on le communique et on dit ce qu'on fait et on fait ce qu'on dit.

Margot: Mille mercis pour votre temps, je pense qu'on a pu faire le tour.

M Fichot. Pas de soucis, bonne continuation pour la suite.

Appendix 17 - Interview with Arthur Duquesne, Business Manager at Nestlé

Margot: Merci beaucoup pour ton temps aujourd'hui. Pour commencer sur le status quo, je me demandais comment Nestlé aujourd'hui assure la traçabilité du soja dans ses produits ?

M Duquesne: Alors le soja c'est un ingrédient très polémiqué souvent à tort. Premièrement pour l'aspect santé ; il y'a certaines personnes qui disent que les phyto œstrogènes présent dans le soja pourrait générer un dérèglement hormonal chez l'humain. Divers sujets sur le soja reviennent comme quoi ce ne serait pas bon. Ensuite le coté environnementale, ou le soja est associé à la déforestation, et aux glyphosates et pulvérisation de masse. Ces deux sujets sont compliqués, il y a toujours un fond de vrai, mais où il y a souvent une solution aussi et sur lequel Nestlé travaille afin de s'assurer que ça ne pose pas de problèmes. Sur l'aspect santé et nutritionnel c'est la légumineuse qui en termes de protéines a le meilleur

taux d'absorption, et en plus de ça, contiens tous les acides aminés essentiels, donc des acides aminés que ton corps ne produit pas mais que tu es obligé d'aller chercher dans la nature donc c'est top et en plus de ça, c'est riche en fibres. Aujourd'hui les Belges ont tendance à manger trop de protéines, mais c'est un faux problème. Par contre le Belge a un déficit en fibre donc c'est super positif. De l'autre côté environnementale il faut voir d'où vient le soja, comment il est cultivé et tout le transport qu'on lui inflige. Aujourd'hui ce que Nestlé essaye de faire c'est de sourcer le plus proches de nos usines. Notre usine principale pour Garden Gourmet elle est en Tchéquie, assez centrale en Europe. Et on essaye de rapatrier toute la production de soja en Europe, plus particulièrement en Serbie. Aujourd'hui 50% de notre soja est Européen, 50% qui vient des Etats Unis. Le but c'est au fur et a mesure de rapatrier, on a certain produit, toute la gamme "Sensational" qui va être 100% Européen en 2022, ça fait partie de la stratégie d'être neutre en carbon d'ici 2022. Et après le but c'est que tout le sourcing viennent d'Europe, y'a des complexités techniques car le soja que tu cultives en Europe ce n'est pas le même dû aux conditions de climat mais aussi des contraintes financières, pas mal de choses entre en considération. Y'a aussi la manière dont le soja est produit, qui est très important, si tu regardes les plantations de soja mondiales, 80% est utilisé dans l'alimentation, 20% pour le bio-ethanol etc, et de c'est 80%, 98% c'est pour le bétail. Aujourd'hui dont la manière qu'on fonctionne, c'est le consommateur final qui prends des décisions, il ne regarde pas ce qui se passe en début de value chain il se focalise sur ce qui est proche de lui. Nous on est zéro GMO aujourd'hui car c'est interdit en Belgique, mais c'est ce qui empêche aujourd'hui d'avoir 10 000 hectares de soja en monocultures, ou tu rases la forêt amazonienne pour les planter et tu viens avec des canadairs de glyphosates tu bombardes, toute la faune et la flore meurt, excepté la plante de soja, et après tu viens avec ta moissonneuse et tu récupères. C'est de la bien sûr que viennent les problèmes environnementaux. Maintenant, Nestlé pourrait se dire qu'on ne source pas de là, mais là on fait partie de RTRS, et la y'a un engagement de sourcer de manières responsables mais aussi d'essayer de promouvoir et de responsabiliser la production. In fine c'est un peu ce qu'on fait, d'un point de vue traçabilité on sait d'où vient notre soja, et on fait en sorte qu'il ne soit pas dans des zones à risques de déforestation, et en plus de ça on joue un rôle actif dans le RTRS pour faire en sorte d'améliorer le sourcing de soja en général.

Margot: Revenant sur cette certification RTRS; tu penses que c'est fiable ?

M Duquesne: Ça c'est comme pour tout, tu auras les mêmes problèmes dans tous les sourcing de matières premières du café au cacao etc. Ce n'est pas parce qu'il y'a des exceptions et des gens qui arrivent a contourner que ce ne sont pas des bonnes initiatives. Nous on veut être 100% clean donc on ne source même pas du Brésil, mais je crois que toutes ces certifications et les gens qui vont sur le terrain ont un rôle majeur à jouer. Les entreprises font également faces a des gros trade-off entre environnement et sociétal. On a l'impression que l'huile de palme ou le soja cela vient de gros agriculteur mais quand tu regardes de plus près tu vois que ce sont que des petits producteurs. S'ils ne rasent pas un bout de forêts ils ne savent pas se nourrir. Donc dans nos chaussures d'Européen on a du mal à se dire que s'ils ne font pas ça ils ont aucun revenu et il meurt de faim. Donc le dilemme c'est soit on travaille qu'avec des gros producteurs qui sont à 100% certifiés et ont un contrôle sur leur value chain, ou on accepte de continuer avec les petits producteurs afin de leur donner une source de revenu tout en faisant un travail de responsabilisation et on essaye de pousser avec des labels et de pousser la durabilité. Et c'est très dur ici, car si on arrête la déforestation ça a un impact social immense.

Margot: Tu ne penses pas que ce trade off environnement et social il est dû au fait que les fermiers ne soient pas payés au juste prix ?

M Duquesne : oui c'est sûr, mêmes les producteurs entre eux, le très gros il a plus de marge que le fermier individuel après ce sont des phénomenes de marchés qui sont difficiles à gérer. La chaine de valeur de base, depuis l'ingrédient de base qu'on transporte, qu'on crack qu'on transforme etc elle est super longue donc c'est compliqué d'avoir un impact là-dessus. Dans notre document, "Responsible Sourcing" de Nestlé sur papier on essaye de rémunérer chacun correctement. L'impact sociale aussi de rémunération de ces petits agriculteurs c'est aussi compliqué car c'est un individu qui va aller dans des zones dé-forêstées, puis mettre au prix le plus bas afin d'essayer de vendre son soja.

Margot: Donc Nestlé ils assurent leur traçabilité via RTRS pour l'instant?

M Duquesne: Oui, en plus de cela on a aussi des auditeurs qui vont sur place afin de contrôler. Le soja c'est un peu la protéine de l'avenir, donc on veut s'assurer d'être nickel de ce point de vue, sur Garden Gourmet, ce sera la première à être neutre en carbone d'ici 2022, financièrement c'est un désastre d'être neutre en carbone d'ici 2022.

Margot: Le fait que le soja soit intégré dans un produit et qu'il soit complètement transformé, tu penses pas que les gens sont moins conscient comme le cacao ?

M Duquesne: C'est un autre sujet ça, car y'a des gens anti transformations, un phénomène très localisé sur la France et la Wallonie. Tu te retrouves finalement dans les mêmes phénomènes de marchés, tu vas te retrouver a produire dans des pays qui sont d'un point de vue financier pas du tout comme l'Europe, et on joue ça depuis notre position d'Européen. Notre rôle en tant qu'Européen et consommateur c'ests que cela se passe le mieux possible, car in fine, ONE PLANET.

Margot: La traçabilité c'est une grande priorité pour Nestlé ?

M Duquesne: Oui fatalement, Nestlé si on vends des produits finis a nos consommateurs, une entreprise qui fait 90milliards de chiffres d'affaires, on a plutôt intérêt a savoir ce que y'a dans nos produits, sinon on est plus dans la maitrise. Donc oui, le but c'est de garantir au maximum la traçabilité, et au maximum savoir d'où viennent nos ingrédients malgré le fait que si t'achètes a un Cargill qui achète a un autre etc, tu ne peux que mettre des règles et contrôles.

Margot: Quels sont les moteurs alors derrière cet objectif de traçabilité pour Nestlé ? (Pouvoir demander un prix premium aux consommateurs ou améliorer votre position compétitive ou plutôt des contraintes tels que la régulation?)

M Duquesne: Ce qui est important a savoir c'est que tous les claims « we are carbon neutral, transparent etc » les gens ne paieront pas plus cher. Ce qu'il se passe c'est que y'a peu de

gens intiment convaincus de certaines choses (manger bio, manger vegan etc) ces gens ils ont un low share of sales mais un immense share of voice. Seaspiracy, c'est un exemple, tout le monde en a entendu parler, ils représentent la communauté vegan. Demain, tu lances du plant based fish, ça génère très peu de ventes. Et c'est pareil pour toute les thématiques et c'est bien, tu vas avoir des activistes, des ONG, des législateurs etc qui vont mettre la pression pour faire certaine choses mais ça n'a pas de valeur réelle ajouté sur ton produit fini. Même si tu fais un survey, tu interroges 100 personnes ils vont dire qu'ils seront prêt a payer plus cher, en réalité, et dans les faits si tu augmentes ton prix ils vont chez le concurrents qui sera moins cher et peut-être moins durable etc. Ca c'est un point important, est ce que ta traçabilité a une valeur pour le consommateur final, en fait non. Quand tes une très grande entreprise, cotée en Bourse, t'as des prérequis qu'on attends de toi tels que : une roadmap carbon, la traçabilité de tes produits, un bon nutriscore etc. C'est l'attente du marché, de ce qu'une multinationale doit faire, et je suis d 'accord avec ca, on représente 3% du marché mondiale alimentaire, c'est notre devoir d'être durable, traçable et garantir des revenus correct à nos agriculteurs.

Margot : Quel est ton opinion justement sur la blockchain et la traçabilité ?

M Duquesne : On travaille déjà un peu avec la blockchain pas sur le soja mais avec Mousseline. Je sais pas pourquoi on l'utilise pas a plus grande échelle, probablement parce que c'est compliqué à mettre en place. Typiquement dans le cas de notre Mousseline, l'usine est dans le Nord de la France et on source toutes les pommes de terres autour de l'usine. Donc c'est super clean comme produit en terme de traçabilité, durabilité et transformation. Dans ce cas las, tu scannais le paquet de Mousseline et tu voyais que la pomme de terre venait de tel champs, les infos sur la récolte etc. On a un contact direct avec le producteurs. Donc la t'as encore plus de traçabilité et visibilité et tu peux mettre en place des choses comme ça, ce qui est plus compliqué lorsque tu as beaucoup d'intermédiaires.

Margot : Oui en effet, le nombre d'intermédiaires joue un rôle, mais alors plus ils sont loins aussi, plus c'est compliqué parfois d'avoir accès aux mêmes infrastructures, formations etc.

M Duquesne : Oui après la Mousseline c'est 99,99% de pommes de terres, donc c'est pas transformé. Le soja on achète de la proteine de soja, et pas des graines donc on achete qu'une partie du soja qui a été cracké donc il ya pas mal d'intermédiaires avant qui eux rassemblent divisent etc.

Margot : Tu penses que dans le futur Nestlé l'implémentera ?

M Duquesne : Je pense qu'on va se diriger vers de plus en plus de ça, si tu regardes l'agriculture au sein de Nestlé dans les années à venir, on va être de plus en plus local, de plus en plus durable et régénératif également. A partir du moment où tu rentres dans ce modèle la d'agriculture régénérative, tu rentres beaucoup plus dans des partnerships avec des fermes, des coopératives etc, et donc tu assures déjà plus de traçabilité. Après ton produits finis il est composé de plusieurs ingrédients, on vends pas juste des tomates donc il faut voir ce qu'on trace. En Belgique on pourrait se dire, on produit beaucoup d'haricots et petits poids, on a lancé un lait végétal récemment, Wunda, il n'est pas encore en Belgique mais c'est à base de petits poids Belges et Français. La ça pourrait être plus facilement appliqué car on est sur du 100% régénératif en plus, neutre en carbon dès le départ, c'est ça la beauté des nouvelles marques que tu crées, tu mets dès le début des standards. Le jour ou le soja est 100% Européen, on pourrait faire cela aussi.

Margot : Quelles sont les challenges pour toi alors pour cet implémentation ?

M Duquesne : Un premier challenge c'est de se demander, est-ce que si on implémente cette traçabilité, et si demain t'as un QR code, est-ce que tu vas le scanner ? Puis une fois que tu l'as scanné, est-ce que tu vas le refaire ? Donc quel est la réelle valeur ajouté de cette traçabilité, oui tu peux dire que t'es durable et que tu es local, mais si je mets « made in Europe » c'est la même chose. Donc est-ce que toute cette implémentation technologiques vaut la peine si le consommateur final ne l'utilise pas ?

Margot : Je parlais a une autre FMCG, et ils parlaient de pousser le consommateurs à utiliser les QR code via le biais de promotion par exemple ? (tu scan 10x des produits et tu reçois une promotion)

M Duquesne : Après est ce qu'on veut rentrer dans une société ou des que t'achètes quelque chose tu scannes ton produit ? c'est comme Yuka, c'est un truc de malade, tu vois vraiment les additifs que y'a dans ton produit, c'est super objectif, des que y'a une FMCG qui les contacte ils disent qu'ils sont impartial, tout le monde a utilisé Yuka mais est-ce que tu l'utilises encore ?

Margot : Oui je l'utilise.

M Duquesne : Si tu fais tes courses chez Delhaize en Belgique tu vas utiliser Yuka ou le nutriscore ?

Margot : Oui le nutriscore c'est vrai, après Yuka c'est plus précis, et c'est là que la blockchain va plus loin c'est qu'elle ne dit pas seulement ce que y'a dans le produit mais aussi l'origine etc.

M Duquesne : Oui la question c'est de savoir jusque ou on veut aller et comment tu valorises vraiment cette Blockchain. Car ce sont de gros couts, une grosse implémentation et comment tu valorises ca au près du consommateur.

Un second challenge c'est qu'il faut revoir tout le modèle. On est dans des transitions immenses, on mange de la même manière depuis des siècles, mais la on en vit une. L'agriculture régénérative ça va être une explosion, tout le monde a des roadmap carbon, et l'agriculture régénérative c'est un des seuls moyen d'atteindre ces objectifs. Y'a rien a faire l'agriculture et la production des produits, c'est ce qui émets le plus de carbon, les gens pensent directement au packaging mais c'est minime par rapport à l'agriculture. Chez Nestlé 8% de nos émissions viennent du plastiques. Pour revenir a la traçabilité, c'est de voir comment l'intégrer avec cette révolution agricole, ou mettre les priorités en sachant

aujourd'hui que les priorités sont sur les empreintes carbon, je pense que ce sera plutôt dans le monde d'après, lorsqu'on aura un nouveau modèle agricole que on va pouvoir implémenter la blockchain.

Margot : Pour revenir a RTRS, tu penses que la pression vient d'eux sur vous ou plutôt de vous sur eux ?

M Duquesne : Je sais pas trop te répondre en particulier pour RTRS. Mais de facto, tous ces labels ont des objectifs claires, c'est d'améliorer la situation actuels. Ces objectifs sont probablement influencés par les membres car ils doivent être réalisables, si tu mets des objectifs non réalisables personne voudra faire partie de cette certification. C'est une concertation entre les deux, mais de toute façon ça va vers un mieux. Dès qu'un objectif est atteint, des nouveaux objectifs sont fixés. On est sans doute consultés mais pour rester a bord faut aussi atteindre les objectifs. C'est aussi un must have d'un point de vue marché, c'est-à-dire que d'un point de vue boursier, les BlackRocks etc ils investissent dans des entreprises plus durables, tu peux pas être la plus grosse boite food and beverages mondiale et pas faire attention à cette durabilité. D'un côté on a envie d'y aller, d'un autre on a envie d'y aller. Au-delà de le devoir pour le marché, on le doit aussi pour le consommateur. Par contre, on a d'un point de vue consommateur final très peu a y gagner. Tu peux le voir dans toutes ces grosses entreprises, on est dans un challenge monumentale, le marché se libère, on sort d'une crise, le pouvoir d'achat de certaines personnes est limité etc. Donc tu peux pas commencer a augmenter tes prix des que t'es bio, local, durable etc. On est dans une situation de marché avec de nouveau standards, auquel il faut répondre, trouver en interne une manière de les intégrer dans ta chaine de valeur. C'est un challenge pour toute les multinationales FMCG de répondre à ces standards, tout en continuant de grandir, être rentable etc.

Margot : Ok merci beaucoup pour ton temps Arthur, cela m'a très fortement aidé.

M Duquesne : Pas de soucis, avec plaisir, bonne journée ! ☺

Appendix 18 - Interview with Estefania Frontero, Ex-Sociologist in Argentina, end-consumer of soy

Margot: Maybe you can start by introducing yourself, and what's your experience with soy?

Ms Frontero: Okay, well, I am a Estefania. I am an Argentinian sociologist, I'm living in Barcelona since 2019, two years already. Well, I actually don't have much experience in soy industry to tell you the truth. I studied the soy production in Argentina, just because it's very important in an economic sense, but I work in marketing and branding in a graphic design studio here in Barcelona, I am a strategist and a consultant for business.

Margot: What's the name of the company again?

Ms Frontero: Mucho.

Margot: Yes right, and Mucho did the branding of the soy milks.

Ms Frontero: Yes.

Margot : Can you tell me about more about Argentina? What you could see there and the main problems?

Ms Frontero: in Argentina, the thing is that the soybean production is the main source of export. And it's like a monoculture because more than 60% of the of the planted area in Argentina is focused on soybean production. And of that, more than 90% is for export, mainly to China and India. So it's like one of the main sources of economic income in Argentina. So it's very, very important but it's also has a lot of consequences. Indeed, we don't have other sources of income or we don't have other productions because soybean is really the biggest ones. It's followed by sunflower, but it affects other productions that could be developed. It is also highly concentrated because almost 5 companies have more than 50% of the production capacities.

Margot: Yes I wanted to reach out to those companies and the farmers more in particular, but it is quite hard to have a contact and reach them out. If you have any contact I would be super grateful.

Ms Frontero: I'll see if I can get you any contact, but I doubt and I imagine must be also very hard to speak with them because they are very connected in with politics, and the government and I don't know if they will be willing to speak.

Margot: Is deforestation a big problem in Argentina? What are the main problems behind this high amount of cultivated soy?

Ms Frontero: I don't know how to explain it very well in like in technical terms, but I know that it affects the soil , the territory that is planted with soy can't be planted with anything else for years after this. There is a lack of biodiversity and if you want to plant anything else in those territories, it's impossible. So it's a vicious cercle, it becomes even more monoculture. Another consequence is the contamination, as they use a lot of Monsanto products (fertilizers, herbicide etc..), this is bad for people's health in the nearby areas.

Margot : for you as consumer, is traceability in your product consumption important?

Ms Frontero: I think it is, of course because, well, there is a social and cultural trend, that now people want to be more informed, we have more tools, and people want to know more about the origin of their food, how is the supply chain, etc. I think that this is a trend that is becoming more important by the day. And well then, of course, we want to know where our food is produced, who produced it, if they care for the environment & sustainability, etc. Oh, that's another consequence of the monocultures.

Margot: You were saying that traceability was for you important, would you be ready to pay like a premium price to gain more, like traceability in your daily food consumption? Or is this something for you a standard, which should be set, and which everyone should respect?

Ms Frontero: The second, of course, I think that it shouldn't be more expensive to know where our food comes from. I think it should be our right. Because, well, it's very important to know where food comes from. And I think that everybody should access that information. But I know that this that doesn't happen. So yes, I will be willing to be to pay more. But that generates more inequality, and not only well in the access to healthy food, but also inequality among information because it should be really accessible for all.

Margot: Yes, that's super important. I think you're right on this completely. And I see also food companies know that, even with more traceability people are not ready to pay like a price premium, you know. What do you know about blockchain?

Ms Frontero: I know very little about blockchain. But I know it's a technological tool that allows us to have more traceability and well, to make the process more transparent

Margot : would you believe this could be a potential solution to traceability and to increase this traceability?

Ms Frontero: I really don't know the technical aspects of it. But I think that, of course, we should leverage all technologies that we have acces, and if blockchain is the one, we should use it. Well also , in order to also make it cheaper and more accessible, that would be the idea. Blockchain shouldn’t make the product more expensive.

Margot : And would you if you had like a QR code, which you had to scan in order to see where the product is coming from? Would you personally do it?

Ms Frontero: Yes, I would I do it, when I buy things in places that have this option, I do it. But also for curiosity, because I want to know how it works.

Margot: Would you do it all the time?

Ms Frontero: Oh, I think that if I do it for every product, I would spend three hours in the supermarket but I supposed I could do it for the one I buy the most, and for the ones I'm more interested in knowing where its produced. Also if I want to know a bit more about the company that produces the product I would do it.

Margot: Yes and this implies also that when they start doing it, , companies will also pay more attention to where the product is sourced from. And you were talking about the farmers before, they have a lot of pressure from governments and politics, do they also have a lot of pressure from traders ?

Ms Frontero: Yeah. Well, I think it's both ways. I think it's also the pressure coming from outside because, for example, almost 90% of the of their production of soybeans for export is for China. And China also makes a lot of pressure on the Argentinian government to reach this amount of export. It's a political tool. I think that some years ago, also United States made a lot of pressure now some of the export has been stopped from Argentina to the US. It's a political tool that the governments use to make pressure on one another. So I think that there is a lot of pressure outside and also insider in Argentina, because it’s very important for the economic growth. I think that in Argentina, it is needed a structural transformation, to make it a more diverse country in economic terms, you know, to have more industry, there's almost no industry in Argentina. There is a need to have another sources of economic growth, not only in our agriculture. But we have a lot of crisis continuously, and if we are focusing on the short term growth, well, obviously soybean is the best source of short term incomes.

Margot : Yeah, but for Argentina is bad to be dependent on only one culture, and what about the remuneration of farmers ?

Ms Frontero: I looked up information because I wanted to reflect a bit. So I can tell you exactly. Well, 10 companies concentrate 80% of the production. So the rest this 20% are all small and medium producers.

Margot: Yes companies like Dreyfus, Cargill etc.

Ms Frontero: Yeah, most of these companies are foreign. Very few are from Argentina.

Margot: Yes and those companies have like, kind of a community of producers, which are reporting to them, you know. It is also difficult for producers to make the right margins because they are reporting to big company.

Ms Frontero: Of course, they pay very few to the actual producers, you know, to the farmers. I think I have the data of how much the farm the farmers earn. But the farmers are the ones that lose the most.

Margot : Yes that's, also the big problem. And I think their blockchain could also can come into place, eventually, with smart contracts, , is the government pushing for this traceability or not at all in Argentina?

Ms Frontero: actually no. Because they are focused on the short term, it to be delivered with with such crisis, even worse with the corporate situation. They are concentrated on paying the debt and reaching the minimum economic stability. So they are not focused on developing technologies. But actually they are startups working in traceability and blockchain. Two might be interesting for you, I can sent you both. This is a startup that is starting to use blockchain developing and it's like an marketplace that centralizes all the business operations.

Margot : quite interesting. So people are trying to remunerate farmers fairly? There is this increasing awareness though.

Ms Frontero: Yes, but I don't think this is reaching the customer. Yeah, no, this is like more for the producers, for the farmers maybe. But well, as I told you, the production of soybean in Argentina is more for export, so consumer are not aware of this. I hope this will be better in the future. Molinos is one of the big trader producing industrialized products for the final consumer, so they might implement blockchain in the future.

Margot: what's your opinion on certifications?

Ms Frontero: Certifications are really relevant for the consumer, also, to know that this product has a guarantee. I think it's also a tool for the consumer to know that this product is is healthy, and it was developed consciously, and it was produced respecting the producers, etc.

Margot: Thanks a lot for all the information. If you have any document which is relevant don't hesitate to share it!

Mr Frontero: No worries; if I can add something it's that traceability should be accessible to everyone and easily accessible. And also, it's important to develop the awareness of consumers as well and to explain to consumers why it is important to know the traceability of our products. So that consumers become more conscious, more respectful for the environment and for the people working on this.

Margot: But thanks a lot for all the information.

Ms Frontero: No worries it was a pleasure.

Appendix 19 - Interview with Emese Van Maanen, Managing director ProTerra Foundation

Margot: Well thank you for being here today. So maybe I can introduce myself quickly. So my name is Margot. I'm currently 24 years old. I'm studying at the Louvain School of Management , nearby Brussels, and I'm currently writing my thesis on how to soy traceability could be enhanced via blockchain. So, yeah, maybe you can introduce yourself, tell me what's your experience with the soy industry?

Ms Van Maanen: Absolutely no, thank you for reaching out to us. So my name is Emese van Maanen I am located and live in the Netherlands where the Proterra Foundation is also founded and registered, I started working with soy around almost 15 years now in many different areas. So I was you know, responsible for feed and food safety in laboratories then I

was managing livestock trading and then you indirectly get connection to soy, after which I was in head of international trade and sustainability. And in the International Trade one of our major commodities was soy, that was back in Switzerland, and after that I move to Netherlands to take this position. So well practically when my connection with the Proterra Foundation is I've been a board member since I think seven years because I was working on the other side. So my ex company was the second biggest buyer of Proterra certified soy in Switzerland and that's how I met the chairman and got connected and got more involved and connected and got elected as Managing Director.

Margot: What is currently ProTerra offering with this certification to companies?

Ms Van Maanen: What is the standard? So, it is based actually on the Basel criteria for Responsible so that was published back in 2004. The standard itself was the first version was created in 2005 and the Proterra Foundation and an independent Dutch foundation is since 2012. So practically what we aim is really to cross promote good agricultural practices you know, our goal is to offer fully traceable non-GMO ingredients for feed and food production, protect the environment but also workers and communities. So that very briefly was the standard about it's a very comprehensive standard and it covers all major elements of sustainability. I don't know if you've seen but it's structured in a way that it has 10 principles, for example, you have “adoption of good agricultural practices of water management”, so there are the topics for the 10 principles that it's a structured. Under the principles you have the indicators, these indicators may be core or non-core and you have to comply to be certified with 100% of the core indicators and with 80% of the overall standard, including core and non-core.

Margot: How do you ensure that companies do comply with those indicators? Do you have like external auditors which are going on the field and then audit?

Ms Van Maanen: What’s important to mention, it's not only about soy, ProTerra is a multi-crop standard, we have increasing amounts and volumes of, for example, sugar cane that we certify every year. And it's, it's a standard that can be applicable globally and to any level in

the supply chain. So not only agricultural production. So we have practically the ProTerra protocol and in terms of certification, which are publicly available documents that define how and who can certify. We have third party certification bodies, indeed, that are trained by the Proterra Foundation. And they are the only ones that can conduct audits against the standard. So they have their own checklists, you know, the auditors and then it takes place on site or virtual, or both, the new hybrid forms. Last year was a challenging year, we had to also adopt new very new practices that we never did before. But I have to say it's surprisingly going on well, surprisingly well. So that is how we ensure that the standard is kept. Traceability is extremely important to identify how the product has been produced, without traceability, it's very difficult to say that your product that you're purchasing is fair.

Margot : What are the current challenges you see in this traceability system today? Do you see like kind of some corruption even with those standards, people not complying to this? How can you ensure for example, that the crops are 100%, non GMO free?

Ms Van Maanen: if they don't apply with the standard, they don't get the certification for another year. So it's every year that they the audit takes place. It depends what the non-conformities are, as I mentioned, if they don't reach this 80% they are not, compliant. But there are some no-go's for example, if child labor or deforestation is found, then they are automatically excluded, because we have a cutoff date of 2008

Margot : Excluded for always or only for one year?

Ms Van Maanen: Well, they may apply again. It is very important that you allow companies also to improve their sustainable development, it wouldn't be sustainable if you would just exclude them because they would produce it anyway in a non-sustainable way, and they will sell it anyway, you know, to countries or continent where sustainability is not an issue. So, for us, it's important and it's also defined in the protocol under point 6.5, how the non-conformities are treated. And then they have a certain amount of months to actually send proof to the certification bodies that they have corrected. In many cases, you know, this is administrative, something that they forgot or wasn't documented. I mean, there's a lot of

paperwork also involved when it comes to certification and many farms just you know, they don't like that that much. Traceability is also a very important part is of course, the flow of the documents and analysis for example. The word segregation can refer to many different things, you know, it can be product segregation, it can be origin segregation, it can be certification segregation, but the only thing where you cannot apply mass balance is GM, that always has to be 100% segregated, because of the cross contamination. So, we mainly focus on physical material, we don't have that credit system, for example, like RTRS does. Because, for non GM, we believe that this is the best way and on the demand side, it's more, something physically needed for the non GM markets. And this is something that really is all the way along segregated or analyzed, and we have the documents called TCCS. That traceability certificates we have that have include that traceability information on the document. And say for example, if you are a buyer in Belgium, and you buy Proterra certified material, you request a TCC then you will have the Brazilian producer all the analyzed system, you will see the states where the soy is coming from. You will see then the part that left Brazil and also the analysis again, many cases done by certification bodies. And then you will see the part that arrived. And then your volume practically on the TCC on the traceability document and your name that it you're the receiver.

Margot: Yeah, I see here, you have a lot of like paperwork and administration. Blockchain could be one of the ways to bring all of this together and share it with others, did you thought of this before? ?

Ms Van Maanen: blockchain is a very interesting and good technology. Currently, we do not use it. It would be simply too expensive for commodities in general used in the livestock industry, because we have seen many years ago, maize, for example, where they, you know, practically marked certain parts of the corn and then it went through the chain, and it was traceable. But that is something that's not feasible today, economically. Technologically, everything's possible today. On the buyer side, the buyers are mainly focusing on the traceability of their shipment, they want to know which areas it's coming from, even if something happens, they want to go back to farm level which is possible, which is really possible because if you use the traceability documents, you register every step, so it's kind of

a soft blockchain, so you don't have really every single soybean, you don't know exactly where it's coming from, but you know, where the shipment is coming from. And, for example, a very important topic today is land use change and their as it has the cutoff date of 2008. In order to make sure that no land use change under which deforestation, there are interviews made, documentation that is checked, and satellite imagery. Today, that is what is really commonly used for these checks. Because on satellite imagery, you really have today, very high quality available data, that helps you really, and you automatically get a signal, if there was any change, even a hectare changed, in the last couple of years. So that is some technologies we commonly see that they are used during audit. And blockchain is in many cases used more for food products. We saw a few projectiles in Belgium or here, you know that you can scan the QR code. That's not something that's feasible for soy. And I think personally that it's also due to the kind of the nature of the product that many cases consumers don't even know they have soy in the products. It is also difficult to communicate also that for example, the chicken ate soy, you know, the consumer general consumer doesn't have that information.

Margot: In my case, it would be more soy used directly for food products for example, in the soy milk.

Ms Van Maanen: that's what I wanted to mention. There, you see, some pilot projects. And that is something that's feasible, because the big part of soy is used for feed, but for the food production, you have higher margins, and you have more awareness. So for those cases, it would be doable, and in many cases you do see pilot projects that for example soy milk or you know, tofu products or meat replacement products, you see that people have QR codes.

Margot: Now, I was wondering if food companies, get this this pilot and people can scan those QR code via blockchain, do you think certification schemes would be then additional to this blockchain? Or do you think it’s exclusive?

Ms Van Maanen: I think it can go only together because, the certification involves not only traceability, but all the social, economic and environmental elements as well. So you cannot leave those out. Because if you trace back, you want to also have that kind of information,

that environmental information, and how it has been produced, you know, so I think it can go very well together is just a different level of traceability. And it's also in many cases, for food. it's also easier, because the volumes are much smaller, and there are less producers involved, and in many cases, they are also more stable. So, it's something that could be really developed. And I think that's also a thing that you could combine with the audit. If you're already visiting, you know, every single player of the chain, then to add that additional information is much less of an effort, then doing it parallel.

Margot : I think also as you said, soy used directly for food companies is really a small part of the total soy industry. And so tracing this only smart part is much easier than tracing the 80% of the total soy worldwide which is used for livestock and others. So yeah, that's one of maybe the opportunities we can see there.

Ms Van Maanen: And in many cases, also, it's regional, so it makes it easier, or there are fewer producing countries as well. Because for food, you need a very different qualities with very specific segment of the soy production. But you do see it definitely among consumers, increasing awareness, increasing pressure, it's all about trust at the end, you know, if you're a consumer, you don't really care about labels anymore. If you go to a supermarket, you just that supermarket offers you fair products. And , even if it's not like that, what people perceive it, that okay, if I go to this supermarket, I receive fair products. I think that's a very important element of it. Because, you know, 10 years ago, it was very different, there were intense discussions about how much information a consumer should receive. With the pure cause, you know, the positive side is, you have a farmer story behind it. And it automatically, I think, creates that emotional connection and trust that you really need for sustainable discussions.

Margot : Do you think then this blockchain implementation would come from retailers or from FMCG companies?

Ms Van Maanen: Well, it depends, in many cases, food companies are really directly working together with the retail sector. So but I definitely think it comes from the end. So either the food processing companies or the retail companies, so it's really good coming from the end of

the supply chain. That is I think that's feasible. Because if we look at traders, they will never implement something that they cannot sell. It's just in the nature of trading. And producers wouldn't invest in something that's not requested, so that that's why it has to come from the end of the supply chain. And it we're talking about also very expensive technology. So it has to be embedded there.

Margot: What are the challenges to this potential implementation you think?

Ms Van Maanen: Transparency and costs , that's my view because it's a very expensive technology, so if you know companies do not see the turn bound, the back profit or advantage of implementing such a technology, then they will not start or will only start with very small pilots. And more in the feed sector, many, many traders don't like to give their information. I don't know if you have seen the soil transparency coalition report, I think that would be also interesting for you, I will send it to you. It was published last month. It was exactly looking into, okay, which trader is willing to offer which kind of information? It is really interesting.

Margot: Yes, I would be super interested in this. I tried to have some interviews with Cargill, or Dreyfus companies like this. But it's really hard to reach them.

Ms Van Maanen: Yes, definitely. No, I'll send it to you. And you have exactly those names also in it that you've just listed.

Margot: Another challenge I was thinking about was more maybe more the infrastructure at the low level, the downstream actors as farmers, they do not have the exact yet the same level of infrastructure.

Ms Van Maanen: Honestly, if I look at the farmers, even in India, everyone has their smartphone, even the smallholders. It's amazing what happened in last few years. I mean, everybody has their smartphone. And this is how, for example, companies that provide the inputs, such as pesticides, seeds they work through the smartphones. So I don't think technology would be today that big of a barrier. Of course, you have certain regions, yes. But

if you look at the big soy producing areas, I think those wouldn't be such a big problem. I was surprised so much in India, that everyone works with their apps. So I don't think that that kind of technology would be a problem. More what could be a problem is that today, we collect data everywhere, we have a huge amount of data. But at the end the most critical question is, what is the quality of your data? Because you can send out questionnaires, but if nobody fills in seriously, then it doesn't work. You see many companies really collecting data, but not actually interpreting it, and not using it in a way they could. So I think that's the more important part of it, collecting data with the apps etc., technologically isn't the problem, it's more how do you really convince the actors in the chain to provide you that data? And then at the end of the second step, what do you do with that data?

Margot: That's what alpro was telling you have to incentivize the end consumer to use the data you're providing, if you're providing such traceability, they should make sure to scan this QR code. But I was wondering also, regarding the standard , who is setting the standards for ProTerra, is it like kind of a tradeoff between companies and between ProTerra ?

Ms Van Maanen: So, what's important is that we update our standard regularly. And it's always followed by a public consultation. So it's, of course, the companies that use proterra. but you know, you have the NGO side where happens much more. So that's why I think public consultation is an efficient and a good way of really updating something like a standard, because you have every side of every stakeholder. You have governments, you have NGOs, the companies themselves, producers, all are asked to send their feedback, and that's always taken into consideration. So it is, it's not only that, if food companies want something simpler, that will happen, because then you would lose your reputation and credibility in the NGO world. And I think it's more the other way, standards are really getting stricter and more comprehensive every time they update, because there are so many topics popping up. We even had our version 4, it's obligatory, to implement since 2020, and already now we see so many new topics coming in that we will have to add in the new revision. And so it's a very dynamic field, and it's increasingly taken up speed. And you know, the inputs you get from stakeholders is just really there. And the public pressure is huge. And then the changes and the development are very rapid.

Margot : And do you believe like companies, if they increase this traceability, they will charge a premium price? Or do you think it's just like kind of a guideline and a standard for the public but people will not be ready to pay a premium price for this?

Ms Van Maanen: The problem is, we see that companies really want this and this and this, and they have a huge set of criteria, and they not in many cases, they are not willing to pay much more. But I personally believe that as you see the developments going on today, sustainability and as a part of sustainability, traceability will be a part of the practical license to operate. It's the same discussion that you had 20-25 years ago with food safety. It has become the license to operate. And I do think sustainability is going in that direction as well. So you will simply not be able to sell your products, at least not in Europe. And I hope that Asia will pick up too if you don't have certain basic criteria that you have implemented.

Margot : Okay. Well, thank you. I see time is running, but thanks a lot of all the information.

Ms Van Maanen: Thank you for reaching out and if you get a lot of success and a beautiful summer period after.