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Agribusiness Supply Chain Management through Digital Innovation: Sustainability versus Traceability.

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Abstract

Blockchain technology is considered as a type of disruptive technology and as one of the first tools of Industry 4.0 today.

It evolves in its applications and its characteristics adapt to increasingly diverse business processes, from cryptocurrency to business transactions, from supply chain control to customer communication. Its adoption by companies has led to profound changes in their business models.

Blockchain can be a strategic lever in the agri-food supply chain to reduce food waste and increase awareness of what is consumed, as higher quality products have a positive impact on consumers' health and quality of life.

The aim of this research is to analyse the use of blockchain in the traceability of the agri-food chain, in order to ensure transparency, provide a secure way to track and transfer resources through supply chains, and limit the risks of food fraud and safety.

It is important to bear in mind that its introduction is not just a technological innovation. It is a real business model that affects the whole life of a company and is used in different production sectors. It increases the effectiveness and efficiency of a company's sustainability policy and helps even smaller companies to communicate directly with all actors in the production chain.

To demonstrate these hypotheses, we will use representative case studies located in the Puglia region. The companies will be treated as best practices, because thanks to these technologies they have been able to innovate their products and expand their markets at national and international level.

Keyword: Blockchain; Supply-chain; Sustainability; Agribusiness

1. Introduction

Over the next decade, agri-food systems will have to cope with disruptive forces such as globalisation, overpopulation and climate change. According to United Nations estimates (World Population Prospects 2022), the world's population will grow from 7.7 billion today to around 8.5 billion in 2030, 9.7 billion in 2050 and 10.4 billion in 2100. By 2050, the number of people aged 65 and over worldwide is expected to be more than double the number of children under 5 and about equal to the number of children under 12.

The negative impacts of the global food chain on climate and environmental degradation (energy and resource use, deforestation, CO_2 emissions), but also its vulnerability to these impacts, are now evident and documented (Food and Agriculture Organization of the United Nations 2017; Kastner et al. 2012). A recent study published in Nature Food (Crippa, et al. 2021) shows that 34% of all global anthropogenic greenhouse gas emissions are caused by agri-food systems, of which 70% are due to agriculture and land use.

Innovation is essential to respond to changing consumer preferences, increased competition, demographic changes and global economic policies, as well as unexpected events that may have serious social and environmental consequences, including extreme weather events and pandemics. Innovation offers perspectives, advantages and concrete responses to current challenges, ensuring greater quality and food

safety through the development of more efficient, conscious and sustainable agri-food systems capable of addressing all the pillars of sustainability, i.e. the economic, social and environmental dimensions.

The prospect of sustainable development in economic, social and environmental terms, following major challenges and structural changes, requires the creation of resilient ecosystems, which in turn can only come from innovative processes. In this context, digital technologies represent a key factor capable of innovating the agricultural sector, transforming production and distribution processes through new sustainable business models (Yu Cao et al. 2022).

Based on the considerations carried out, in this work we want to analyse how blockchain technologies can facilitate the company in obtaining and communicating a sustainable production process, based on the characteristics of the agri-food chain in terms of transparency, traceability and food safety (Rana et al. 2021), and the use of production processes that limit environmental pollution (Horton et al. 2016).

2. Introducing digitalisation to the agricultural supply chain: blockchain

Digital innovation is playing an increasingly important role in making the agri-food sector more sustainable. From Agriculture 4.0 solutions to technologies used in the transformation and distribution phases, digital technology makes it possible to use inputs more efficiently, reduce waste, improve working conditions and ensure economic sustainability.

The growth trend of digitalisation throughout the agri-food chain didn't stop with the Covid-19 crisis.

According to the Agrifood Smart Observatory, run jointly by the Politecnico di Milano and the University of Brescia, Agriculture 4.0 has continued to grow in Italy over the last two years. The market has gone from a turnover of 540 million euros in the first half of 2020 to 1.6 billion euros in 2021.

At the same time, the area cultivated by farms using Agriculture 4.0 tools has grown. This area reaches 6% of the total area in 2021, twice as much as in the previous year, but still low compared to the average of other competing countries.

More than half of farmers are adopting 4.0 farming practices. The applications concern precision farming systems used in the production process: land mapping, control and monitoring of agricultural machinery or crops. Other applications concern business management upstream in the planning phase or downstream in the marketing phase.

More and more players in the agri-food chain are recognising the opportunities and benefits of digital innovation, which is now a strategic lever for the resilience and competitiveness of the sector.

It is important to consider the vitality of the sector also in terms of its capacity for innovation and development on the main technological platforms, in order to achieve the three main objectives that primarily qualify this path of innovation: economic and social sustainability, efficiency and competitiveness of companies, and awareness of the new levels of knowledge that data make available to companies and people.

Blockchain projects in the agri-food sector are growing exponentially, and among the stated objectives, those of a commercial nature predominate (54%), followed by supply chain efficiency (47%), sustainability (26%), improving food safety (13%), anti-counterfeiting (11%), payments and transitions (11%). This is in contrast to the demands of the end consumer, who puts the need for traceability of the supply chain first.

Moving the analysis to the last link of the supply chain (Smart Agrifood Observatory report), from the results of a questionnaire administered to a sample of over 1000 consumers, only 6% know the application of blockchain in the agrifood sector and 60% have never heard of it.

Those who claim to be aware of it see it as a useful tool to ensure transparency and traceability in the agri-food chain, which is identified as one of the priorities of consumers.
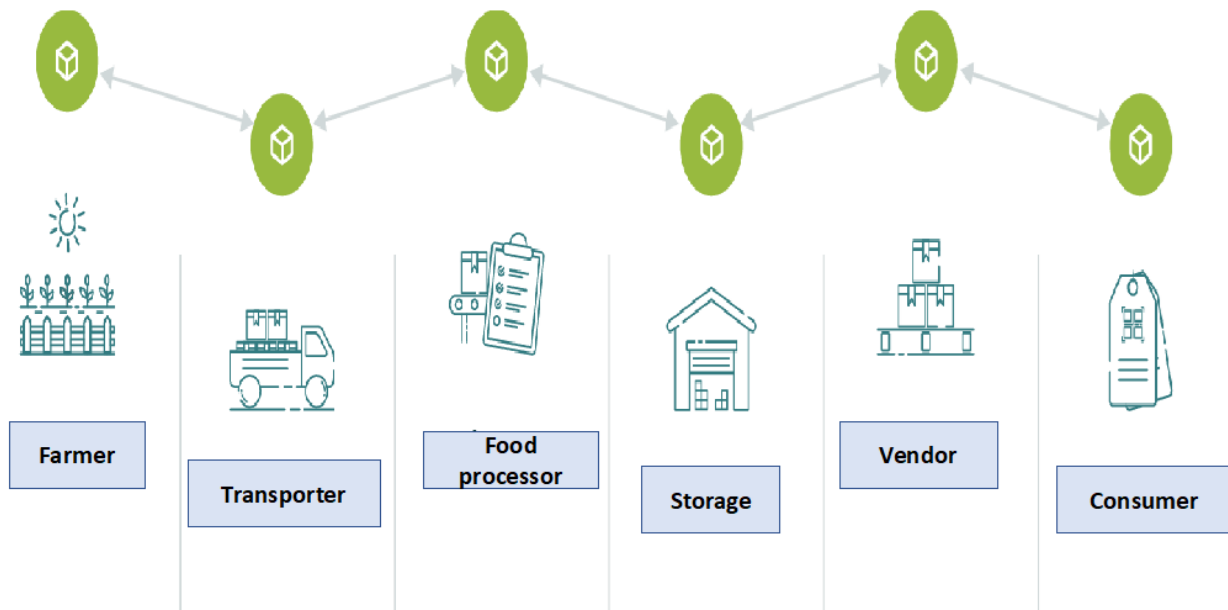
Fig. 1 Agribusiness supply chain integrated in a blockchain

3. Literature Review

Blockchain is an implementation of distributed ledger technology that emerged in 2008 following the publication of a white paper by Satoshi Nakamoto, although initial work dates back to the 1990s (Bayer et al. 1993, Haber & Stornetta1991).

It is a cryptographic technology that allows information to be placed in a peer-to-peer network system to prevent tampering.

The ledger, as a database, is made up of different blocks linked in a chain and is accessible across different locations and by multiple participants.

BT eliminates the role of a third party or intermediary to control and oversee the system. Instead, it uses a transparent consensus mechanism that ensures that only valid transactions are executed (Nakamoto, 2008;).

All operations are visible to participants in the network, and therefore BT prevents malicious activity by participants (Kamble et al. 2020).

There are two types of blockchain applications: the permissionless, a public blockchain, and the permissioned, which is a private blockchain. They differ in that permission is or is not required to become part of the blockchain network and contribute to its maintenance.

The permissionless blockchain is a better solution for business transactions to show traceability While the public blockchain has proven to be an excellent solution for the currency trading market, the private blockchain is becoming an institutional solution for conducting business with transactional efficiency and managing the provenance and traceability of goods in supply chains).

The supply chain can be defined as "the set of activities, from production to distribution, that bring agricultural or horticultural products from "the farm to the table." (Ahumada & Villalobos 2009),

Agri-food supply chains are complex to manage due to several factors, such as the number of actors and stakeholders involved, the short product characteristics, and the complexity of the supply chain (Pearson et al. 2019).

The production, processing, distribution and marketing sequences (Tsolakis et al., 2014) are supported by logistical, financial and technical services (Kelepouris et al., 2007).

Supply chain management is a complex set of all the processes, systems and strategies involved in optimising the supply chain. The main purpose of this process is to control the company's performance in order to optimise its efficiency and ensure that demand is met at all times.

Through properly optimised supply chain management, companies are able to become more competitive at the market level (Bhatnagar R. & Sohal A.S 2005) and at the same time increase customer satisfaction.

In order to improve consumer trust and willingness to buy, the food chain must become more sustainable. Tracking and certification of information throughout the food supply chain is crucial to identify and address sources of contamination, which contributes to sustainability management in agri-food chains (Feng et al. 2020).

In addition to improving transaction transparency, food safety and quality, and reducing food fraud and waste, it serves as a digital solution for reducing operational costs and improving efficiency in food supply chains

In addition to helping increase transaction transparency, food safety, and quality, and reduce food fraud and waste, it serves as a digital solution for reducing operational costs and improving efficiency in food supply chains (Kunpeng Li et al.2021; Kumar et al.2022; Karlsen et al. 2013)

While the best known application of blockchain is bitcoin, this technology has other relevant applications in sectors such as agrifood or logistics, as it combines transparent and trustworthy storage with IoT, allowing users to trace goods from their origin to consumption (Ferrandez.- Caramès & Fraga - Lamas 2018).

The agrifood supply chain is very complex to manage due to the number of stakeholders mentioned and the product characteristics, which depend on the environment such as weather and transport.

4. Methodology

Based on the reference background, the following research questions were elaborated:

Q1 Do companies implement blockchain to achieve goals directly related to sustainable development?

Q2 Do companies implement blockchain to ensure product traceability?

Q3 Enterprises implement blockchain to achieve goals related to competitive advantage?

A Framework has therefore been developed including the following steps:

1) Analysis of the literature in order to identify, for the agri-food sector, reference topics for the identification of sustainable development goals, product traceability and competitive advantage deriving from the adoption of blockchain.
2) Identification of the cases to be examined, favoring the aspects of homogeneity not only of the sector, but also of territory and size.

Carrying out the analysis through:

I. primary sources, interviews with managers involved in the blockchain implementation and management process
II. secondary sources through companies' websites and search engines.

5. Results and Discussion

The cases were selected because they were particularly suitable for this analysis and, according to the companies considered, represent a best practice in the adoption of blockchain technology for the certification of the production chain, each in its own sector of reference.

The analysis carried out, essentially qualitative, selected the main themes for each of the research questions, taking into account the existing literature, and sought them in the examination of the documents examined and the interviews conducted with those responsible for the implementation of blockchain technology in the company.

The three cases were selected according to homogeneity criteria: they are located in the same region, Puglia, are micro enterprises and have implemented blockchain on a single production line, limiting their investment, at least initially.

The cases examined are:

1. Placido Volpone s.r.l. winery

PLACIDO VOLPONE

2. Buondioli Farm

3. Pr.ali.na s.r.l.

1.The Placido Volpone s.r.l. winery was founded in 1974 and is located in Puglia, in the province of Foggia; the vineyards are located in a hilly area of the region and the production process is carried out in accordance with ancient techniques, using innovative equipment.

The case studied represents an international best practice for the certification of the production process through the use of blockchain technology, implemented to guarantee the origin and quality of the products (Tiscini et al. 2020).

The production is divided into three different product lines: Vini d'autore (Il Rosso e il Nero; Rosàntica; Calce Viva), Wines in Purity (Rosone; I cinque figli; Faragola), Vini Saggi (Altomare; Beniamino; Mimì).

Cantina Placido Volpone is the first winery in the world to certify its wine supply chain on the blockchain, a project carried out in collaboration with Ernst & Young and EzLab to certify the first wine in the world at "virtual km 0".

As they report on their website, blockchain allows consumers to control the production of wine from the grape to its transformation into a bottle, tracing and certifying every step of the production process.

On the label of the bottle, there is a QR code that allows the consumer to identify the wine and access the information related to the product. When the scanner (a simple QR reader on a smartphone) reads the QR code, it opens a web page with details about that particular bottle.

The information provided relates to the geographical context in which the wine was produced, the cultivation methods, information on the use of pesticides and fertilisers, information on the stages and methods of the production process and, finally, information on the quantities distributed and the distribution channels used.

In conclusion, from the analysis of the primary and secondary information sources studied, Cantina Placido Volpone declares that it will use the blockchain to achieve the following objectives:

- Traceability of the supply chain, indicating all stages of production, but starting with the origin of the raw material;
- Transparency on the use of pesticides and fertilisers, substances that are harmful to the environment and to health. In this way, the producer takes responsibility for their correct use.
- There is no explicit reference to food safety, but it can be included in the previous claims.
- Differentiation from other competitors is a goal that the implementation of the blockchain sets itself. The traceability and transparency of the production chain is a certified guarantee of the authenticity of a product made in Italy.

2.Buondioli, an ancient oil company founded in 1864 and now in its fourth generation, is based in Carpino, in the province of Foggia. It has always focused on the innovative management of a traditional product, first starting a process of brand enhancement and, since 2018, focusing on the digitalisation of the production process, on which blockchain technology is also based.

The digitisation process was launched in collaboration with X-Farm, a start-up specialising in precision farming techniques, and DNV, an assurance and risk management company specialising in supply chain and product assurance.

The project to digitise the production process of organic Gargano olive oil, a typical local variety, was launched by X-Farm, which installed an X-Sense weather station to record the agro-meteorological parameters essential for intelligent management of the field. The photos taken by the sensors during the operations, together with the information on transformation and bottling, are the data processed by the

XFarm system and returned to the end consumer in the form of a story through "My Story", DNV GL's blockchain-based digital assurance solution.

Traceability and transparency of the supply chain are always the primary objectives of the digitisation process implemented.

The greatest benefit in terms of sustainability is always to ensure traceability and transparency of the supply chain. The production of an organic oil whose process is traced, certified and communicated, the consumer buys a quality product that is safe for his health and sustainable for the environment. The certification in blockchain also guarantees that no polluting products are used, as the olives are grown organically, this aspect is emphasised.

The competitive advantage is mainly focused on innovative process and product strategies, which make it possible to combine the tradition of the production process used with a digital system capable of reaching new consumer goals.

3.Pr.ali.Na is an agri-food company founded in 1991 in Puglia, in Melpignano, Lecce, by a group of professionals who wanted to enhance the products of the territory through a processing company.

After thirty years, the production of food preparations and sauces is organized in six production lines: Pralina, I Bio, Le Biodiverse, Il Piccolo Bio, Ristorante Italiano, Passandpartout.

Pr.ali.Na is a company that has always focused on innovation and internationalisation, so much so that it is currently present with its products in over 30 countries around the world, both with its own brand and with private labels. The project to introduce blockchain began in 2018, in collaboration with the start-up Foodchain, and was the first in Italy for this type of product. The project involved one of the production lines, Le Biodiverse. The mapping of the processes was carried out by Pralina, while Foodchain built the digital interface and subsequently accompanied the company in its use and application. The interface is directly linked to the company's management system, which manages the business processes from the arrival of raw materials to the unloading of the warehouse, the production phase, quality and production controls, labelling and dispatch. Pralina's declared objectives are traceability and transparency of the production process, but also the enhancement of the territory. To this end, a memorandum of understanding has been signed with local producers for the conservation and promotion of specific local crops.

This project of territorial and also social valorisation has been traced with the Blockchain technology, thanks to which the consumer can see the entire production process, from the origin of the raw material to the purchase, thanks to a QR code printed on the label. The economic objectives that the company is pursuing with the blockchain are aimed at penetrating international markets, where the traceability of the product is intended to transmit the culture of the territory.

Conclusion

If we carry out a comparative analysis of the three cases studied from a technological point of view, the results are similar. In the three companies, a permissionless blockchain project is implemented by a startup - Foodchain for Pralina, Ez-lab for Placido Volpone and X-Farm, DNV for Buondioli - and consumers access the information through a QR code placed on the product.

The three companies also share a common approach to sustainability and traceability.

Two of the companies surveyed, Placido Volpone and Buondioli, do not refer to sustainability, only Pr.ali.na explicitly mentions compliance with ESG sustainable development goals when mentioning the land improvement project.

The main objective of the companies is traceability and transparency, although when the companies pursue the objective of traceability, they mention respect for the environment by limiting the use of pesticides or, as in the case of Buondioli, the fight against the waste of water and resources.

Companies are thus indirectly influencing a sustainability process that is also pushing for a new way of thinking based not only on sustainable consumption, but also on sustainable production.

Thus, the answer to the first and second research questions is positive: traceability remains the top priority of blockchain adoption in the agribusiness sector, but companies indirectly state that they also pursue sustainable development goals through blockchain.

The three companies studied are achieving economic goals through blockchain, confirming the third research question.

Cantine Placido Volpone reports that the greatest competitive advantage is differentiation from other competitors. For Buondioli, the competitive advantage is innovation in the production process and in the distribution phase. This allows the company to focus on innovation and to promote its history and tradition. Praline claims to have adopted blockchain for the internationalisation of its products, communicating the local culture abroad.

This research has implications both for agribusinesses wishing to initiate sustainable development and digitisation processes, and for policymakers who could encourage such technologies through direct funding of companies or projects to disseminate this technology.

Digitalisation and sustainability are the two pillars on which the PNNR is based. The PNNR (National Recovery and Resilience Plan) is a financial plan designed to stimulate the development of the Italian economy after the crisis defined by Covid 19.

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