UNIVERSIDAD DE BURGOS

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BACHELOR THESIS

Blockchain Applications in Food Marketing

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INDEX

RESUMEN

Este Trabajo de Fin de Grado analiza los fundamentos de la tecnología blockchain para obtener un conocimiento básico sobre lo que significa, su origen y evolución, su funcionamiento y las ventajas que ofrece sobre otras tecnologías digitales. Se presenta brevemente la utilidad de esta tecnología en los distintos sectores, pero, sobre todo, se detallan las aplicaciones y ventajas del blockchain en el marketing alimentario. Para una mejor comprensión, se analizan algunos casos de éxito y, por último, a fin de determinar el grado de conocimiento y aplicación del blockchain en el sector agroalimentario de Castilla y León se realiza un estudio empírico a través del análisis de los resultados de una encuesta contestada por 48 empresas.

PALABRAS CLAVE

Blockchain, contratos inteligentes, trazabilidad, cadena de suministro, fraude, marketing alimentario

ABSTRACT

This Bachelor Thesis analyzes the fundamentals of blockchain technology to obtain a basic knowledge about what it means, its origin and evolution, its operation and the advantages it offers over other digital technologies. The usefulness of this technology in the different sectors is briefly presented, but above all, the applications and advantages of blockchain in food marketing are detailed. For a better understanding, some success stories are analyzed and finally, in order to determine the degree of knowledge and application of the blockchain in the agri-food sector of Castilla y León an empirical study is carried out through the analysis of the results of a survey answered by 48 companies.

KEY WORDS

Blockchain, smart contracts, traceability, supply chain, fraud, food marketing

1. INTRODUCTION

Who has not heard about the *bitcoin*? Undoubtedly many people know that it is an electronic currency, which appeared in 2009 created by someone only known by his alias "Satoshi Nakamoto." It is also known that the value of *bitcoin* has been growing since then, and that at present, it is an investment in high demand by financial operators. We may have also heard that it is a cryptocurrency, but, what most of us do not know, is the technology that made the creation of this currency possible (Dolader & others, 2017).

The *blockchain* is that technology. Its main contribution is that it allows the transfer of goods and services in a way that guarantees total security, without the need for an external entity to certify the transactions. At a technical level, this is achieved thanks to the encryption with cryptography, through a blockchain system. The advantages of this system are countless, as it prevents security breaches and theft from happening, ensuring that the records that are entered into the network are true and unalterable (Pastor, 2018).

In recent years, there have been numerous events related to the blockchain in Castilla y León that demonstrate the growing interest in this technology. In this sense, the Technological Institute of Castilla y León (ITCL), promoted the celebration in Valladolid in March 2019, of the first *National Blockchain Forum for SMEs and companies* with more than 100 participants (ITCL, 2019). In Burgos, in December 2020, the Digital Innovation Hub Industry 4.0 (DIHBU), held a meeting on *Artificial Intelligence, Industry 4.0, Digitization and Blockchain,* which brought together experts in this field both from Burgos industries and at the national level (BURGOSconecta, 2020).

In the food sector, this technology takes on special importance, since the supply chain has many links that makes it difficult to achieve full transparency and traceability. The need to comply with traceability regulations to guarantee the quality and safety of food products and the fight against fraud and counterfeiting are aspects where the blockchain can be very useful for companies in the sector, who are already beginning to implement this technology. (Lage, 2019)

1.1. OBJECTIVES

The first objective of this Bachelor Thesis is to obtain a basic knowledge of what blockchain technology is. Its origin and evolution will be analyzed to understand what it has meant in the financial and business

sectors in which it has begun to apply and also the potential it has for any other sector, both at the level of large companies and small startups.

The second objective is to study the importance of the application of this technology in the agri-food sector, in aspects as important as traceability and transparency in the food supply chain and the fight against fraud, fundamental both for companies and for the confidence that their products must generate in the final consumer. The impact that blockchain can have on the planning of the marketing mix of agri-food companies is analyzed, that involve taking advantage of the competitive benefits that the establishment of this technology supposes.

Finally, the third goal is to determine the degree of knowledge and implementation of the blockchain in the agri-food sector of Castilla y León, by conducting an empirical study and analyzing the results obtained.

1.2. STRUCTURE AND METHODOLOGY

This Thesis is structured in 6 chapters. In the first one, the motivation, the objectives pursued and the structure and methodology used are established.

The second chapter is dedicated to describing the fundamentals of blockchain technology, its origin and evolution and basic operation. The different types of blockchain platforms that exist, the advantages and disadvantages of using this new technology and the different uses it has in numerous sectors are described.

The third chapter analyzes the blockchain in the food sector, its main applications and the challenges of its use. Among the applications are the guarantee of traceability, the fight against fraud and the impact that all of them can have on the company's marketing mix.

For a better understanding, in chapter four, some successful stories of agri-food companies are studied which have already chosen to implement this system in their businesses, such as the Spanish company Campofrío, which has recently implemented this system in its Navidul brand of hams.

Chapter five details the empirical study carried out by analyzing the results of a survey that was sent to 48 companies in Castilla y León, and Chapter six summarizes the conclusions of this bachelor thesis.

Regarding the methodology used, in the first place, a search for secondary information on the fundamentals of the blockchain was carried out to try to understand this new technology and its possible applications both generally and specifically in the food sector. To achieve this, different sources have been reviewed: academic books and articles from scientific journals, but also, since it is innovative and a constantly development technology, other articles from different publications and web pages of companies or associations have been used that serve to obtain a broader and more up-to-date vision on the topic.

Secondly, a search was carried out for companies, associations and official organizations that could have some information about the blockchain application. Thus, the contributions of DIHIBU, ITCL and the VITARTIS website have been very useful.

Thirdly and in order to accomplish the empirical study and collect primary information, the collaboration of the *Servicio Territorial de Agricultura, Ganadería y Desarrollo Rural de la Junta de Castilla y León de Burgos* was requested, whose suggestions on the companies of Castilla y León that could collaborate in the survey were also very serviceable.

Consequently, numerous surveys were sent in Google Forms format, obtaining 48 answers with which the empirical study on the degree of knowledge and implementation of the blockchain in the agri-food sector of Castilla y León has been carried out.

2. BLOCKCHAIN FUNDAMENTALS

Blockchain is one of today's most disruptive technologies, and in the near future, it will be able to transform the business ecosystem by the large number of practical applications it has. In essence, it allows you to create a distributed and non-modifiable database, based on a growing sequence of blocks that, by their technical characteristics, they provide transparency, safety and high resistance to failure and handling. (Dolader & others, 2017)

The blockchain was launched in late 2008, when the cryptocurrency called *Bitcoin* emerged, a digital and electronic money system independent of intermediaries, which was made possible by this new technology that provides a virtually impenetrable security system.

Just as Internet changed business models forever, thanks to unlimited and automatic access to information, blockchain technology is giving rise to a new economic pattern where it will be possible

to exchange goods and services without the need for third parties. That is why some authors already talk about the change from *the Internet of information* to *the Internet of value.* (Preukschat, 2017)

2.1. DEFINITION

The book "Blockchain Revolution" (2016) by Don and Alex Tapscott contains a concise definition of blockchain which defends that the blockchain is an incorruptible digital ledger of economic transactions and also that it could be programmed to record not just financial transactions but virtually everything of value in general.

Essentially, blockchain is a distributed database where the information is collected, recorded and stored in blocks designed to prevent modification once a data has been published. This is achieved by adding, in each block, metadata with information relating to another block of the previous string in a timeline, so, thanks to advanced cryptographic techniques, the information in a block can only be edited by modifying all subsequent blocks.

This means that the blockchain is a digital data record that is "distributed", which means, that it is shared between many different parties, protected by cryptography, which can only be modified or updated based on the consensus of the majority of system participants and whose information can never be erased. Its main contribution is that it allows secure transactions between people around the world without the need for intermediaries or third parties. (Pastor, 2018)

Accurately, blockchain was born out of the need to eliminate intermediaries such as banks and other electronic platforms such as PayPal, in case of financial operations. These institutions certify that we are who we say we are, and in exchange for their services, they keep our data and trade with it. With blockchain technology, it is not just one participant who has the information, but millions of them, so the certification of information is based on consensus.

Furthermore, this technology originated in a context where only a few powerful companies controlled the internet industry, using people's personal and business data. On the Internet, our privacy is completely exposed to these companies and society has few guarantees regarding the transparency of the use that is being made of its data. It is for all this, why blockchain technologies propose to guarantee the security and transparency of any transaction using direct and decentralized connections.

2.2. BLOCKCHAIN ORIGIN AND EVOLUTION

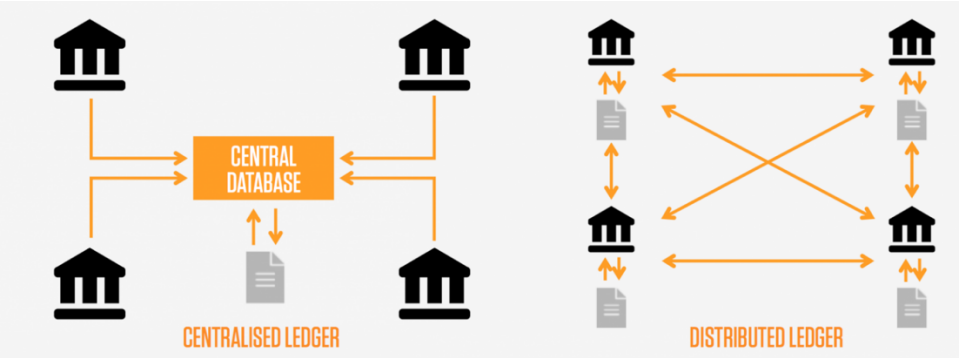
To understand the fundamentals of blockchain technology it is necessary to go back to 3200 BC, when there was evidence of the existence of the first accounting record of a single entry, and, giving way to the beginning of the databases to record the information in a systematic way. In the 16th century, the first double entry accounting system was created, and from then, until the appearance of personal computers and later the Internet, there were hardly any significant advances. (Iglesias, 2018)

The emergence of electronic money and financial transactions through the Internet had raised the need to ensure the safety of operations. Banks and other "safe" platforms certify the money the people have in the account and they ensure that transactions are carried out correctly. Above them, the governments regulate and control that the banks carry out their task correctly. In other words, a central entity is needed to regulate and guarantee transactions.

Bitcoin was born with the aim of being a digital currency, whose transactions were safe and tamper-proof and not controlled by any entity (see Figure 2.1). It wanted to have a system known by all, where no one had to intervene to certify that the transactions are carried out, that they are irreversible and that no one could undone or modified them. In addition, it was intended to be independent from governments so that no one could prohibit or censor transactions, nor authorize or veto access to the system. To achieve this, it needed to get a technology that began to develop in the last years of the 20th century.

In 1991 the work of Stuart Haber and W. Scott Stornetta, led them to develop a chain of blocks for the first time, where documents were stored securely so timestamps could not be manipulated with, using advanced cryptographic techniques. In 1996 the technological bases appear on which the origin of the blockchain will be based, the P2P “peer to peer” connections, which serve to share any file between two or more computers, but without either of them have control over the others. (BINANCE ACADEMY, 2018b)

Figure 2.1 Differences: Centralised & Disdributed ledger.



Source: Tarasenko (2019)

In subsequent years, several authors improved the system until, on October 31, 2008, on the crypto network called *metzdowd.com*, an article of *Bitcoin* signed by the mysterious *Satoshi Nakamoto,* was published for the first time, worldwide known for being the creator of the first cryptocurrency based on blockchain, and therefore the first financial application of this technology. At present, it is unknown if Nakamoto is really the pseudonym of a single person, or of a group of people, but the reality is that, since its creation, trust in blockchain technology has not stopped growing. (Nakamoto, 2008)

In January 2009, *Bitcoin* comes into operation with the first "open-source program", that is, accessible to any programmer (Iglesias, 2018), and the first *bitcoins* were created. In May 2010, the first real transaction with a bitcoin took place (the payment of 2 pizzas in exchange for 10,000 bitcoins by a programmer). Currently the value of this cryptocurrency is skyrocketing and it is valued at more than 49,000 euros (see Figure 2.2).

Figure 2.2 Bitcoin Chart

Source: CoinMarketCap, (2020)

In 2014, a group of developers launched the *Ethereum Project* to create an open-source distributed public platform with blockchain technology for the execution of contracts made digitally, with the same function as traditional contracts, called *smart contracts* (MIT, 2018). Finally, the *Ethereum platform* was launched in 2015, and to finance their development, manage the execution of smart contracts and compensate the nodes that execute them, they also created their own cryptocurrency: *Ether.*

Nowadays, numerous financial and stock market companies such as IBM, have already incorporate this technology as the basis of their commercial business. However, its development will help modernize many other public and private sectors, because of the large number of practical applications that this technology offers and which will be analyzed later in this project. (Iglesias, 2018)

2.3. FUNDAMENTAL ELEMENTS OF THE BLOCKCHAIN

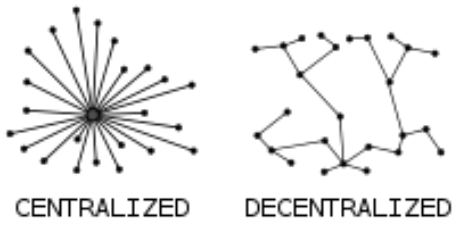
Before explaining the operation of blockchain platforms, it is important to define some key concepts for understanding:

- *Transaction:* the data stored in the blockchain were mainly financial transactions, but currently, within the blockchain, the term "transaction" refers to recording and sending of any type of information. (Bit-Fury Group & Garzik, 2015).
- *Block and blockchain:* it is the database where the transactions are stored in chronological order. Each block stores user records, following a series of procedures that ensure its validity. Once a block is completed, the information is encrypted using cryptography so that it cannot be altered, and it is added to the chain. Then, the emission of the next block starts. (MIT, 2018)
- *Nodes:* in practice, they are all computers connected to the blockchain, which share the same software or communication protocol to be able to share information.

  The nodes are interconnected through a peer-to-peer (P2P) network. Thus, they can communicate with each other to transmit and share data and information through said network without the need of a central controller to manage the transfer of files and information. (Preukschat, 2017)
- *Standard protocol*: the computer software that makes communication between the computers in the node network possible.

- *P2P (peer- to- peer) Network:* in practice it means that all the nodes (computers) that make up the network, act as equals to each other, so, there are no clients or servers, and therefore no hierarchies between them. (Nakamoto, 2008)
- *Decentralized system:* as there are no hierarchies between the nodes, computers connected to the network act as equals, without any external entity controlling them. (Preukschat, 2017) (see Figure 2.3)

Figure 2.3 Centralized and Decentralized System



Source: Dragonchain (2019)

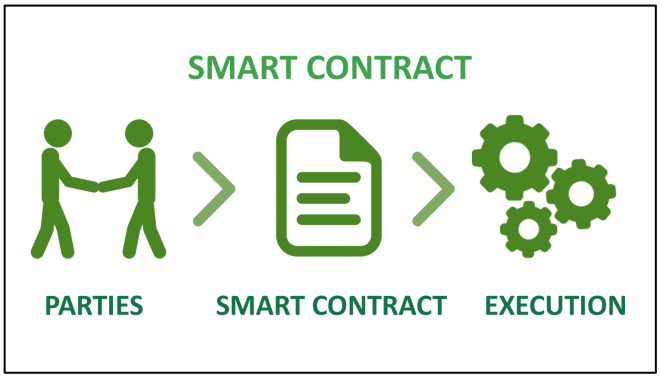
- *Cryptography:* in general, cryptography is the procedure by which a message can be encoded (encrypted) using a key, so that it is incomprehensible to any outsider who does not have the key to the algorithm used to encode the message. (Granados, 2006)
- *Hash:* alphanumeric identifier generated by cryptography, once the block has reached its maximum capacity, used to relate the blocks to each other. Therefore, it is the key or fingerprint that identifies the blocks, which is unique and unrepeatable that cannot be modified. (BBVA, 2018a)
- *Consensus:* it is the common protocol that verifies that transactions have been carried out and guarantees that they are irreversible. It is responsible for providing all users with an unalterable and updated copy of the blockchain. (Preukschat, 2017)
- *Mining*: it is known as mining, the process by which the nodes validate the information of a block. This work consists of performing highly complex calculations, which require a large amount of electricity and computing power. (BBVA, 2018a)
- *Smart Contract*: they are contracts made digitally, which fulfill the same function as traditional contracts, but that they are capable of being executed and enforced automatically, without the

intervention of intermediaries, notaries or other authorities. Thanks to blockchain technology, the security is guaranteed. (MIT, 2018) (see Figure 2.4 & Figure 2.5)

Figure 2.4 Traditional contract

Source: Edith (2020)

Figure 2.5 Smart contract

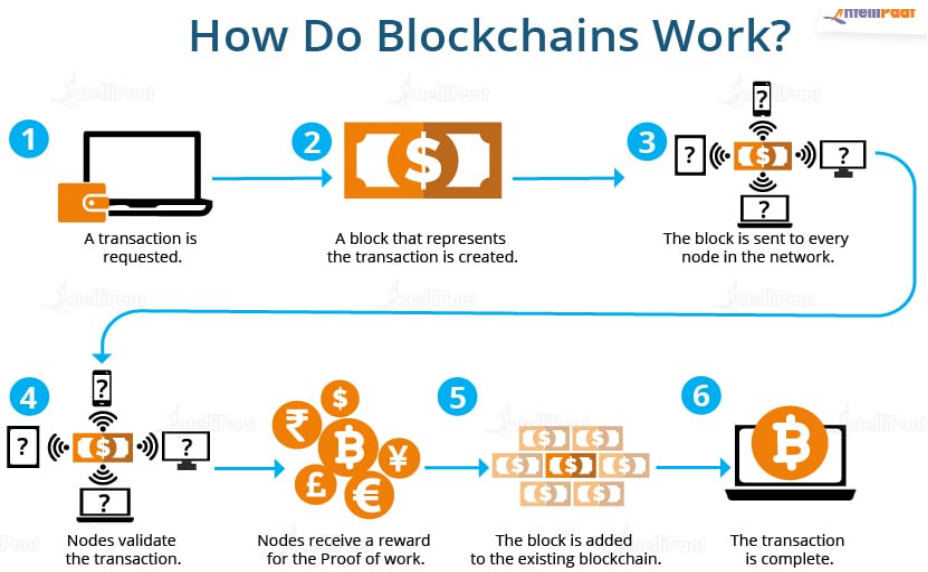


Source: Edith (2020)

2.4. HOW THE BLOCKCHAIN WORKS

The technical operation of the blockchain is complicated, since it requires having basic knowledge of cryptography, which is, in essence, the basis for establishing the security and immutability of the block network. (see Figure 2.6)

Figure 2.6 How Do Blockchain Work



Source: Raj (2021)

Leaving apart the technical aspects, the sequence of operation of the blockchain could be summarized as: (GOLDMAN SACHS, 2018; Raj, 2021)

1.-*Request for the transaction:* the user, who wishes to carry out a monetary or of any type of transaction, must register the data associated with it, in the blockchain platform.

2.- Creation of the block where the transaction is registered: the first block consists of a header and data of the transactions ordered. This timestamp is used to create the alphanumeric string called *a hash.*

Once the first block is completed, a new one is generated, which uses the *hash* of the previous block to generate its own *hash.* In this way, the blockchain has a large number of blocks that are linked to each other (as a string) so that each block contains a reference to the previous one, thus avoiding the possibility of duplicate entries.

3.- *Sending the block to all the nodes (participants) of the network:* the blockchain works as a decentralized database, managed by computers belonging to a peer-to-peer network, so that each computer on the network has a copy of the record-book, avoiding a single point of failure and keeping all copies updated and validated at the same time.

4.- *The nodes validate the transaction*: before a new block can be added to the chain, its authenticity must be verified by a computerized process called *validation* or *consensus*. The process of validating a block by the nodes is known as *mining*. The nodes must use the same *standard protocol* of communication, and they must accept that the *hash* of the new block is correct, certifying that said data is real.

5.- *Nodes receive a reward for proof of work:* blockchain network security is based on the large number of nodes that validate transactions. Therefore, in its protocols, rewards are established for the nodes that use their time and resources to validate the transactions carried out.

6.- *The block is added to the blockchain:* once the nodes have validated the authenticity of the block, it is added to the blockchain. This is how blocks (records) are added to the chain. Once a block has been added, this information can never be deleted or modified, since to do so, the information of all the previous and subsequent blocks should be changed.

7.- *The transaction is completed*.

2.5. BLOCKCHAIN PLATFORMS

There are several types of blockchain, which have been developing since the beginnings of technology, and that are differentiated mainly by their accessibility, the function and the performances they have, because the consensus protocols they require, the flexibility of the network, the transaction validation rules and the level of protection of the identity of the participants. (Preukschat, 2017)

- Public blockchain, also called *without permission*, such as *Bitcoin, Litecoin* or *Ethereum*. They are the first to emerge and are usually associated with cryptocurrencies. They are characterized because it is not necessary to ask permission to access them, and in which anyone can become a user, participate in the network, carry out transactions and participate in the consensus process.

  To use them, all you need is to download the app and connect, due to there is no administrator, so to validate a transaction the consensus protocols must be followed. All users (nodes) on the network are equals so each one has an up-to-date copy and the consensus is established openly.

  Being a decentralized system -there is no central authority-,consensus becomes a complex issue, since it depends on the trust of the participating parties in the blockchain system and is based on the premise that all parties are honest in their actions.

  Due to the large number of participants they support, the speed of transactions is low. Finally, they are said to be pseudo-anonymous, since the owners of the transactions are not known, although the traceability of transactions is possible.

- Private blockchain or *with permission* appeared from the need of some corporations to store large amounts of data that, however, cannot be shared openly, for confidentiality reasons. They use block technology, but they are not considered “true” blockchain, because control is exercised by a principal entity, who is responsible for the maintenance of the chain. In addition, the databases are on a main server that is not public, and it is only accessed by invitation. The entity that controls the blockchain, grants the permissions to the users who want to join the network to make transactions or accept blocks. The speed of transactions is higher, and the entity that controls the platform knows the identity of the participants, so decide the level of anonymity they maintain between them. Many financial entities use this type of private blockchain.

- In an intermediate way, the federated or hybrid blockchain, used both by companies and organizations that generate large sums of money, and by governments. They are characterized because they are not open to the general public, and its management is the responsibility of an organism. They are not associated with cryptocurrencies nor offer rewards for mining blocks, however, they use an open source software.
- Finally, the newest blockchain platforms are the ones called *Service Blockchain* (BaaS), that arose to facilitate the development of blockchain solutions for companies, externally, which represents great cost savings and simplicity of use. Companies like IBM (Hyperledger Fabric), Microsoft or Amazon offer Blockchain Services in the cloud. (BBVA, 2018b)

Table 2.1 Differences between blockchain platforms

	BLOCKCHAIN PLATFORMS		
	Public blockchain	**Private blockchain**	**Hybrid blockchain**
Access	Without restrictions. Permission is not requested to access	With permission. Access by invitation	Not open to the public. Restricted access
Transparency	Total	Sometimes	Sometimes
Security	Consensus protocols	Through a preapproval of the participants.	Responsibility of an organism
Transaction speed	Low	Higher speed	It depends on the number of participants
Anonymity	Pseudo anonymous	Known identities	Decided by the person in charge
Usability	Cryptocurrencies	Financial entities	Large companies, Governments

Source: Own elaboration based on Allende & Colina (2018)

2.6. ADVANTAGES AND DISADVANTAGES

Once the operation of blockchain has been detailed, its main characteristics and specific advantages offered by its use will be analyzed below: (Mitre-Abuhayar & others, 2018)

- *Security:* the main advantage of blockchain is security since it is practically impossible to alter a chain of blocks, because information is shared by thousands or millions of users, and even if one node goes down, all other nodes have a copy of it. Therefore, it allows all types of financial transactions to be carried out safely and reliably. As has already been said, the participation of intermediaries is eliminated, and the users themselves are the ones who have control of the transaction information.
- *Speed:* transactions are carried out immediately, as there are no intermediaries (as in the case of banks), so, it is not necessary to wait for them to be effective. It is a 24-hour system and the information is transmitted and saved automatically.
- *Integrity:* transaction data is immutable and impossible to falsify, modify or delete. As they are decentralized networks, they do not have a central point of error, but rather, to validate the information, the participation of many nodes is necessary, so only one of them needs to be active so that the network does not go down. That is why information is never lost.
- *Transparency and privacy:* this mean, that movements cannot be modified, but they are integrated into the network as a whole and they are public, that is, can be seen by each of the parties.
- *Free of errors in the transmission of transaction data*. The data is continuously checked.
- *Transaction costs decrease.* Traditionally, banks and other payment platforms charge very high commissions to users who use the service. With this technology, the exchange of assets has a much lower cost.
- By not needing intermediaries, the blockchain drives *globalization.* Goods and services can be transferred to other countries regardless of currencies and saving costly red tape.

As for the risks and challenges of the blockchain, they are related precisely to the fact that it is a new technology, which breaks with the schemes and the way of doing business for centuries. Two types of problems arise: ethical and technical (BINANCE ACADEMY,2018a)

Among the ethical problems some of the main ones are:

- The opacity and lack of control of the authorities over the blockchain network and over the owners of cryptocurrencies. It can be exploited by criminal organizations for money laundering and other illegal financial operations.

- Regarding private networks, the possibility allocating the costs of developing the technology to the business lines that use it.

Regarding technical problems, the following can be cited:

- Impossibility of modifying the data: although it is an advantage of the system, it can also constitute a problem if the modification is necessary.
- Chain storage capacity: since data is stored forever, the storage and operational capacity of the strings will be limited.
- High cost for the validation of the enormous volume of data that is handled. It is estimated that the *Bitcoin* network consumes more energy than countries such as Denmark or Ireland. This is a big problem that implies that it should not only try to solve the processing capacity of the network but also reduce the energy it consumes.

2.7. APPLICATIONS IN DIFFERENT SECTORS

In recent years, blockchain has been gradually moving away from being associated only with cryptocurrencies, to penetrate in other sectors and business operations such as: *smart contracts,* fund transactions, policies, and many other applications. (Dolader & others, 2017)

According to a study conducted by *IBM's Institute for Business Value in* 2017, to more than 300 executives from around the world "33% of the companies surveyed were already using blockchain or were planning to use it, and 78% of those surveyed stated that they were studying its use to respond to changes in their sector with the creation of new business models based on this technology". (IBM, 2017, p.3)

Here are some of the most promising applications of the blockchain:

- *Distributed cloud storage*: this has great advantages over services like Google Drive or Drop Box in storing data in the cloud by avoiding hacking problems, or loss of information. (Mitre-Abuhayar & others, 2018)
- *Decentralization of the Internet of Things (IoT):* the concept of the Internet of Things refers to the digital interconnection of the things that we use in daily life through the Internet. It is the basics of domotics, smart-cities and other electronic devices such as smart-watches. The blockchain allows

creating decentralized IoT platforms that allow the exchange of data in a safe and reliable way, creating an unalterable record of the messages exchanged by all connected smart devices. (Rodríguez, 2020). IBM firm has opted for this solution and created the ADEPT (Autonomous Decentralized Peer to Peer Telemetry) platform in collaboration with Samsung. (Pureswaran & others, 2015)

- *Identity management:* using blockchain technology there are companies that provide digital identity creation services, like Keybase, Onename o ShoCard. Users can create a secure, reliable and tamper-proof digital identity. (Mitre-Abuhayar & others, 2018)
- *Immediate execution of Contracts:* one of the main utilities for blockchain technology companies is the use of decentralized platforms that support smart contracts agreements, such as Ripple and Ethereum. (Fernández Espinosa, 2019)
- Materials and products can also be safely tracked as they move through supply chains.

All these applications have begun to be used by numerous business sectors, organizations and governments, among which the following stand out:

- *In the financial sector,* blockchain will allow progress in the ongoing digital transformation, offering a better and more secure service. Banks use this technology to streamline payments and transfers and reduce costs. An example would be the Santander bank, which already uses this technology to carry out very fast international transactions. (Preukschat, 2017)
- *Logistics and Transportation*: this is one of the sectors in which a greater number of agents and intermediaries intervene, generating a large amount of documentation and data exchange. The application of the blockchain could automate document management, notably reducing intermediaries and organizing information in a clear, transparent and instantaneous way. (STOCK LOGISTIC, 2018).
- *Tourism and Hotels:* blockchain technology can be used to streamline reservation management, through *smart contracts,* to facilitate check-in at hotels and airports, thanks to identity management platforms, which would also provide more control to customers over the privacy of their data. As an example, we can cite the TIU Group hotel chain, which, with more than 300 hotels, has developed a private blockchain platform to manage its real estate assets and internal processes. (TECNOHOTEL, 2017).

- *Energy:* the application of blockchain in this sector will streamline transactions between the different agents of the energy trade, eliminating some intermediaries. For example, the article report by Prieto (2019), show that, in Spain, Iberdrola, Endesa and Naturgy they are already using this decentralized system.
- *Insurance:* as in the banking sector, five large insurers (Zurich, Aegon, Allianz, Munich RE and Swiss RE) created in 2016, a blockchain consortium called *Blockchain Insurance Industry Initiative,* to share experiences and projects carried out with this technology. The main application of blockchain to this sector is the well-known *smart contracts*, which will help streamline contracts, increase security and prevent fraud. (Jiménez, 2020).
- *Health Sector*: as IBM blockchain research (2021) has shown, currently, that blockchain services have already begun to be developed for the health and pharmaceutical sector. This technology allows the safe collection and storage of the medical history of patients, so that it can be consulted at any time with security guarantees and maintaining the confidentiality of the data. In the pharmaceutical sector, it can be used to guarantee the traceability and control of the drugs consumed, connecting pharmacies to blockchain networks. (IBM, 2021b)
- *Education:* there are many applications that the blockchain can have in education: creation of platforms to share documents safely to avoid fraud, issuance of certificates and official documents and protection of intellectual property. As an example, the Spanish company Tutellos, has created a blockchain platform called Tutellus.io, to encourage study and reduce school failure, through a system that rewards both teachers for their work and students for their achievements. (Fintech.com, 2017).
- *Other applications*: there are many sectors and activities where blockchain technology is beginning to be applied by developing platforms adapted to their specific requirements. Some of them are notaries and legal sector, elections land registry, sport, art, public administration and the Food sector that will be developed later in this project.

The European Commission is aware of the enormous potential of this technology, so for the first time in 2020, EIC (European Innovation Council) organized a competition, aimed at companies that develop projects focused on guaranteeing social interest with blockchain. More than 100 projects from around the world were eligible for the award and 6 companies were awarded. Among the projects, the Dutch startup WordProof stands out, to regain confidence in the internet and combat fake news through a blockchain tool, which also allows registering the content created on the internet

and claim ownership of it. Another of the awarded projects is UnBlocked Cash Project, which has created a blockchain platform in order that humanitarian aid entities can provide a transparent record that, while preserving the privacy of donors, allows knowing how the money is being spent. As a last example, the British company Project Provenance, which uses this technology with a view to consumers can consult, from their smartphone, information about what product they consume, where it comes from and the ethical conditions in which it was produced. (Rubio, 2020).

3. THE BLOCKCHAIN IN THE FOOD SECTOR.

According to the 2019 economic report of the Spanish Federation of Food and Beverage Industries (FIAB 2019), this sector brings together more than 30,000 companies in Spain, which represent 8% of Europe with a production in 2019 of more than 119,000 million euros. In Castilla y León, the agri-food business industry is represented by some 3,000 companies employing more than 55,000 people, exceeding 10,000 million euros in turnover in 2019, which represents 23.5% of the total turnover of the industry of Castilla y León.

The global pandemic situation produced by COVID19 in 2020 and the economic crisis caused by it, has highlighted once again the importance of this sector for the regional economy, since it has withstood the effects of the crisis much better than other sectors like the automotive or tourism ones. Furthermore, aspects such as food safety or electronic commerce have become especially important for consumers. (Valencioso, 2020)

In this context, according to Beatriz Escudero, president of the VITARTIS Association of Castilla y León, at the 2020 General Assembly of the Association, for agri-food companies, in order to strengthen its position as a relevant sector said: “The key now is to develop the concept of competitive collaboration through innovation, sustainability, marketing and innovation.” (Valencioso, 2020, p.18)

Technological innovations in general and new digital technologies, within which the blockchain is, offer to the agri-food chain numerous opportunities to produce in a more efficiently and sustainably way. The current situation due to the pandemic has revealed abruptly, that digitized companies have been able to continue their activities with many competitive advantages over others. In this new context, the digital transformation of companies acquires a new dimension by becoming an essential aspect for business competitiveness. (Montoriol-Garriga, 2020)

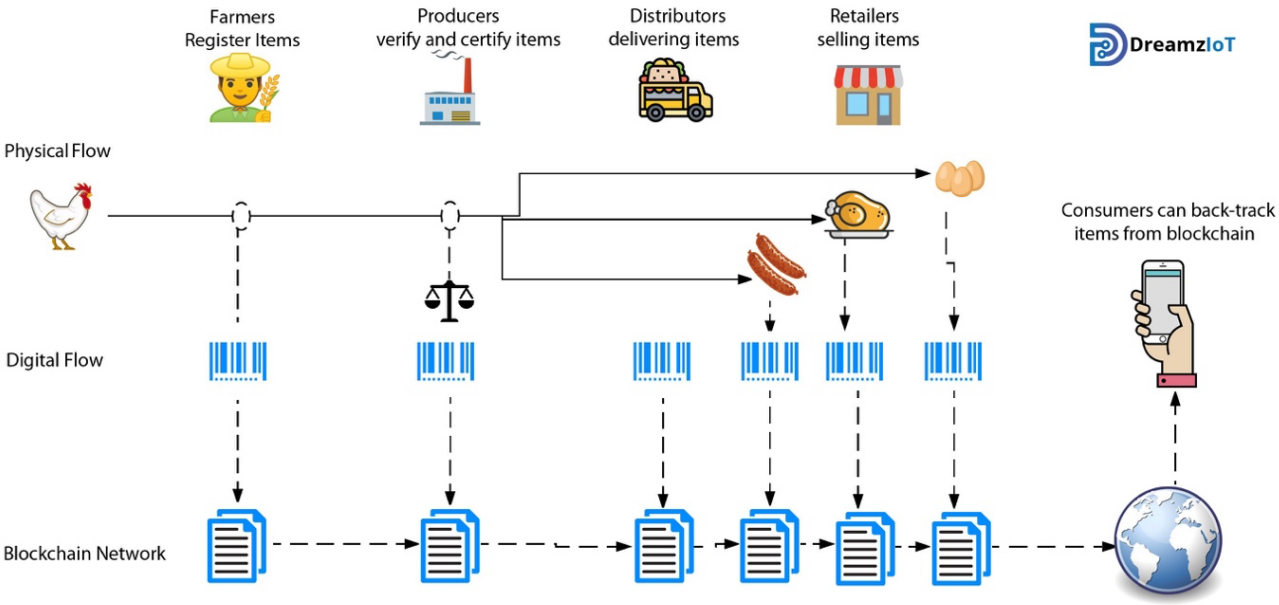
Therefore, the use of blockchain in the agri-food industry does not eliminate digital supply chain management systems, since its implementation depends on the company having the most advanced systems possible for digitally capturing data, and it constitutes one more tool in the digitization process of this sector. (Olmos, 2019)

The advantages of using this technology in the agri-food sector derive from the very demands of the agri-food chain, where concepts such as transparency, collaboration and trust between the different actors, or reduction of costs and time in transactions are essential requirements. The implementation of blockchain technologies in the supply chain of the food industry is a very wise decision by companies, since with it, they could reduce the great problem of food safety, improving traceability, transparency and trust- fraud control-. (Fonts, 2018)

Food security has been an issue that has always concerned society. To improve in that aspect, and to be able to manage and control the supply chain in a more efficient, transparent way and increasing profits, the blockchain in the food industry is already being implemented in numerous companies. (Mena, 2020)

In addition, another impulse from which this movement has benefited is the growing distrust of consumers, who, more and more, want to answer all their questions about, for example, the use of certain insecticides in food, the diet of animals, the ethics of their sacrifice, etc. Awareness of allergies, specific food diets, religious beliefs are also examples of bases that have served as the engine for the blockchain at present days, because consumers need to be sure that the information provided on the product labels is reliable and, the information, complete (see Figure 3.1).

Figure 3.1 Transforming Food Supply chain with Blockchain and IoT



Source: DreamzIoT (2018)

3.1. SPECIFIC APPLICATIONS IN FOOD MARKETING

3.1.1. Improvement of traceability

The Spanish Association of Commercial Codification AECOC (2021), define traceability on its website as "The set of those pre-established and self-sufficient procedures that allow knowing the history, location and trajectory of a product or batch of products along the supply chain at a certain moment, through certain tools".

Traceability in the agri-food sector is especially important, since it affects aspects related not only to the quality and trust of consumers, but with safety, public health and the requirements that the regulations impose on the food offered to consumers. The main objective of food traceability is that, the possible doubts of the consumers have no negative effect on business results. It is very important for the authentication process and the tracing of the products to the primary source or origin, of their distribution and to remove them if necessary or if there is a problem. The labeling has to coincide with all the processes that the certain food has gone through, in order to avoid the possible problems of fraud, falsification of labels and health. (Dalmau, 2021)

Furthermore, it is necessary to highlight the influence of the new generations in business strategies and the need to implement innovative systems that guarantee the quality and origin of food. Millennials and Gen Z have grown up in a digitized environment and they are in continuous contact with the well-known fake news, and thus, they are used to debugging the information in a more efficient way and to look for the one that is closest to reality.

Blockchain technology offers almost perfect traceability of the supply chain. Monitoring the traceability of a product is traditionally based on the need to comply with legislation, using third parties such as independent or governmental associations to guarantee the process. With this new technology in which the data is stored in a distributed way and all participants in the chain have access to them, the information is secure and immutable, and the "external" certifying entities are eliminated, which increases confidence and security. This is especially important in international operations, where errors can be avoided by automating many of the processes and simplify customs formalities. (Lage, 2019)

Several companies already include this technology to ensure the traceability of their products. Nestle started by applying the blockchain to track products from their origin in New Zealand to its factories in the Middle East and already uses it in numerous products. Australian beef vending company, JD.com, allows Chinese citizens, for example, can trace every piece of steak back to its farm of provenance in Australia, with details of the animal, its transportation, food, etc. (Van Rijmenam, 2019) Recent examples are numerous and include all kinds of products as in the case of the British company OCADO, dedicated to e-commerce and home delivery of mainly fresh and highly perishable products from supermarkets, that they can guarantee, thanks to blockchain technology, a reliable and agile supply chain. (Dalmau, 2021)

3.1.2. Fight against fraud

Society has always feared and fears being and feeling cheated. The problem arises when this deception occurs consciously in relation to the quality or treatment of a product, in this case, a nutritional product, with the aim of deceiving the consumer and obtaining an illegal profit. Fraud may well be related to incorrect labeling in relation to quantity or quality, the dilution of a liquid in another of poorer quality (very common in wine), the substitution of a high-value ingredient such as olive oil for a lower-value ingredient, add dyes to food to hide its flaws… (PIXELPLEX, 2020)

Label fraud is one of the most common, in which, when packaging food, It is intended to "deceive" the consumer by placing products of poor or worse quality, labeling them as if they were higher-end, or also, that could be difficult to trace its origin, distribution or treatment. The barcode was the first automated system to identify products throughout the supply chain. Later, QR codes and RDIF technology have been used, capable of transmitting information without contact between a chip and a scanner.

In the control of customs and border procedures, the blockchain allows not only to streamline and automate procedures, but also makes it easier for authorities to control the origin of products in order to apply the corresponding customs tax to the country of origin without the possibility of fraud. For example, the United States Customs and Border Protection (CBP) is studying the use of this technology in several pilot projects ranging from tracking licenses and permits to the certificates of origin. The use of this technology would prevent countries such as China from not paying the corresponding taxes on their products through the use of third countries to enter the USA. (Suominen, 2020)

Through blockchain technology, all members of the supply chain can trace the product, locate historical information and store all data on the origin, composition or quality of food in a reliable, fast and rigorous way. Thus, it can be ensured that all members of the supply chain, from producer to consumer, are be able to track all the information about the products by QR code scanner of their labels, and blockchain technology makes them sure about the veracity of the data presented.

According to data obtained from the JUNIPER RESEARCH (2019), dedicated to the analysis of digital markets, blockchain will allow to reduce 31 million dollars in food fraud worldwide by 2024. Dr Kimmich, author of the research, affirms that the limiting factors for the transparency and efficiency of the supply chain are the opacity of the data, the paper records and the obligation of the companies to depend on intermediaries. Blockchain and IoT save time and resources by providing a shared and immutable platform on which all participants in the supply chain can track products, thus reducing fraud.

Nowadays, there are many companies that have already adopted this technology to fight fraud, for example the American firms Whole Foods, Subway, Chipotle or Five Guys, which have the support of a company that develops specific traceability and food safety software called FoodLogiQ. In addition, the well-known firm Alibaba, is working with AusPost, PwC in order to create a blockchain network that allows them to improve the transparency and traceability of the supply chain of their products. Collaboration with the dairy brand, Fonterra, and with Blackmore, manufacturer of supplements and vitamins, has allowed

Alibaba to achieve this objective in order to increase the reliability and trust of its customers, using QR codes on the labels. (Van Rijmenam, 2018). Another example is Bumble Bee Foods, an American company dedicated to the sale of canned fish, which, thanks to blockchain technology, allows consumers to scan the QR code on tuna and to obtain information on where it was caught and other information that allows it to be certified as fair trade. (Van Rijmenam, 2019)

3.1.3. Compliance with legislation

The food sector is under great pressure from government institutions, and it must strictly comply with the regulations that ensure, not only the veracity of the data contained in the labeling of the products (fight against fraud) but also all those that guarantee the hygienic-sanitary conditions of the products that finally reach the consumer.

Scandals as mediatic as the "mad cow crisis" or the "avian flu" made consumers aware of the importance of demanding strict compliance with the health standards of the food they eat. It is important that companies comply with the regulations, but also that they are able to react and remove the product when things go wrong. Periodically there are news about E. Coli poisoning in vegetables, outbreaks of salmonellosis every summer, or the listeriosis produced by the contamination of shredded meat in 2019. (Fernández Esteban, 2019)

In Europe, Regulation (EC) No. 178/2002 of the European Parliament and of the Council of 28 January 2002, establishes "The general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety."[1] This Regulation has been recently modified by Regulation (EU) 2019/1381 of the European Parliament and of the Council of 20 June 2019 “on the transparency and sustainability of the EU risk assessment in the food chain”[2]. With these Regulations, concepts such as traceability become mandatory so that companies can, in case a problem arises, remove batches in poor condition before being put on the market.

In Spain, the Spanish Food Safety Agency, with the Autonomous Communities, guarantees compliance with Spanish Food legislation. In 2017, the first Agri-Food Law Code was presented in Valladolid, originated from the collaboration of VITARTIS with the BOE which contains a compilation of the hundreds

[1] Official Journal of the European Communities, L 31, 01 February 2002 R(EC) No. 178/2002
[2] Official Journal of the European Union, L 231, 6 September 2019 R (EU) 2019/1381

of most important legal provisions, both state and regional that affect the regulation of the sector. It contains a total of 102 laws, 226 royal decrees, 29 decrees and a legislative decree. This compilation highlights the large number of standards that this sector must comply with. The use of this technology should help companies meet these standards. (VITARTIS, 2017).

Blockchain can facilitate compliance with regulations, by facilitating traceability management for companies, automating the activities of the supply chain in a more efficient and transparent way, as already mentioned.

3.1.4. Access to new markets

The use of blockchain in the food sector is not only beneficial in existing markets to improve its operation, but also has the power to create and promote entry into new digital markets, commonly called *marketplaces*. In them, farmers and agri-food workers will be able to communicate and share information directly with buyers.

As an example, the marketplace Ec21.com, founded in Korea, allows direct contact with food buyers and suppliers in a B2B way ("Business to Business"). (Dalmau, 2021)

3.1.5. Logistics and efficient management

The blockchain offers new opportunities in the food industry to improve all its processes. In the supply chain, the security of blockchain networks allows the sharing of information, managing financial flows and detecting failures in the acquisition or production of raw materials, as well as controlling the logistics of all operations. On the other hand, smart contracts can streamline the management of all operations, reducing transaction costs, improving margins and achieving greater efficiency. (Kumar Sharma & Singh, 2020)

As an example, in Canada, Walmart has implemented a blockchain network with transportation companies that allows them to control all logistics operations. There are also companies in China, like Li & Fung, that seeks monetary financing in different credit institutions using this technology. (Dalmau, 2021)

3.1.6. Blockchain in food marketing

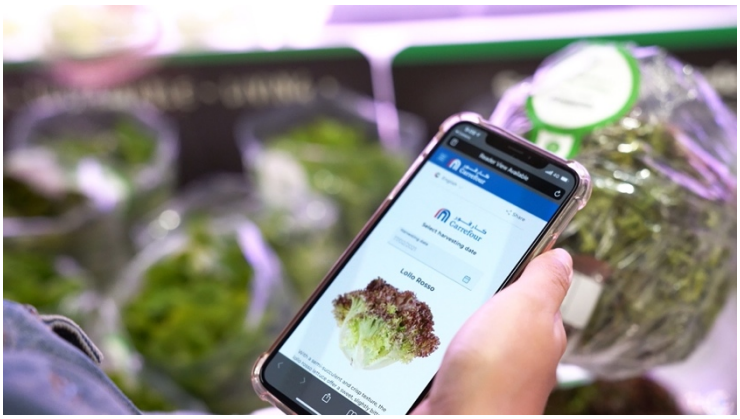
The multiple applications that blockchain technology offers in the food sector have been analyzed, ranging from ensuring transparent and responsible traceability, that enables the security and efficient collection

of information from the origins of products and raw materials, its production, distribution, treatment and finally sale to the consumer, to many other aspects such as logistics control, the fight against fraud, smart contracts and relationships with stakeholders. Organizations can take advantage of all these changes in the marketing strategies that arise within their marketing-mix.

Marketing-mix is defined as the human activities directed to satisfy human needs and wants through exchange process (Kotler & others, 2018). The marketing mix of the company is traditionally based on 4 variables (product, price, place y promotion). With new technologies, including blockchain, these “4Ps” acquire a new dimension: money becomes digital, traditional contracts into smart contracts and consumers increasingly demand to know all the characteristics of the product, could be some examples.

- Regarding the *product,* the marketing-mix must take advantage of the great possibilities offered by the blockchain, which allows, as detailed above, to offer the consumer and all the actors of the supply chain the guarantee of origin, the conservation process, the cold chain, composition or any other data of interest about the product. In addition, it enables companies to fight fraud and counterfeiting, one of the most worrying aspects for many food companies and which entails more efforts in their marketing strategy, to get the consumer to trust the authenticity of the brand. (Gil & Cabrera, 2020). The end consumer, by reading the QR codes on the product label, will be able to access all the information about it, thanks to the blockchain (see Figure 3.2). That circumstance should be considered as an advantage by the company's marketing strategy to guarantee its product.

Figure 3.2 IBM Food Trust to Deliver Food Traceability Across Carrefour Stores Using Blockchain Technology



Source: IBM News Room (2021)

- Second, in terms of *promotion*, the use of blockchain can radically change the way of promoting products through new advertising models, in which advertising companies can communicate directly through blockchain platforms without intermediaries. In addition, marketers will be able to measure the effect of advertising objectively, since the data registered in the blockchain network is unique and unalterable. Consumers will have control over their data, as they will be the ones who choose whether or not to provide certain data to the network when they become users. Also, the use of this technology can help reduce the well-known "fake news", which affect the prestige of organizations so much, and that sometimes make them dedicate great efforts to deny or regain the prestige lost after a fake new. (Maestre, 2019)
- The *place* can also benefit from the application of the blockchain. As already mentioned, through the use of blockchain platforms, transport logistics can be improved, allowing chain actors to verify at all times, not only the place where the product is located but many other information about them. This is especially important in the food industry and particularly in the distribution of fresh products and in e-commerce, where, ensuring delivery in optimal conditions is of vital importance to the company and for the marketing decisions they need to make.
- Finally, as for the *price*, it is a very significant factor when making transactions, since the consumer increasingly consults and compares the prices especially in the marketplace, where companies sell their products online. In this case, the implementation of technology represents a cost for companies, which could mean having to increase the price of the final product. This could be accepted by consumers in the case of products in which the guarantee of quality or origin as quality wine or ham were more important than the price itself, but it would not be acceptable in others. In these cases, they should take advantage of the benefits that the use of blockchain can bring to companies in terms of cost savings by facilitating transactions through smart contracts and other management tools. Therefore, the price invested in implementing this technology would not have to be translated to the final price. (Gil & Cabrera, 2020)

All these aspects must be taken into account by the marketing managers of the companies when planning the marketing-mix to take full advantage of the competitive advantages that the implementation of the blockchain technology in their organization can bring.

3.2. CHALLENGES OF BLOCKCHAIN IN THE FOOD SECTOR

Every new technology, no matter how promising, faces implementation problems which must be resolved if the company wants to achieve a dominant position in the development of the Agri-food Industry 4.0. blockchain is no exception, and it will have to face this challenge.

One of the main challenges of this technology is the need to develop international standards to set the rules of the game so that all parties involved in a blockchain network accept and trust them. Factors such as complexity, verification mechanism, confidentiality and data protection will be limiting for many entrepreneurs. In addition, it will be necessary to take into account that, for many elements of the chain, especially for producers living in remote places or in underdeveloped countries, the application of this technology will be very complex or inaccessible. (Mena, 2020)

Furthermore, many points must be clarified at the legal level, since of the adequate regulation of blockchain in general, depends on its system being accepted by businesses, consumers and authorities as a technology capable of guaranteeing both traceability, labeling, transparency and trust of the food chain, as well as guaranteeing companies the level of confidentiality and treatment of adequate personal data and intellectual property, as well as compliance with current legislation in each country. (Mena, 2020)

It is important to keep in mind that the blockchain is nothing more than another technology, and its development will also depend on its ability to interact with other technologies like IoT, that will allow the elimination of traditional certification processes in the future. IoT solutions link the physical world with the digital one, allowing data such as temperature and humidity to be captured during food transport, and the integration of this data in a blockchain allows that all the participants of the chain can store and access this data. (Kumar Sharma & Singh, 2020)

Finally, it must be taken into account that the costs of implementing the blockchain are another difficulty for companies, and they will have to analyze the possibility that consumers are willing to pay more for the advantages it offers. In addition, currently several giants of Information Technology have created blockchain platforms that they make available to other companies, adapting them to their specific needs, so the implementation of this technology is much more affordable than if each company had to design its own network. Examples include IBM's Food Trust and Watson, Track and Trace, and SAP's Leonardo, Track and Trace, and Oracle's Internet of Things platforms. (Kumar Sharma & Singh, 2020)

Table 3.1 Summary table of blockchain applications and challenges in the food industry

BLOCKCHAIN IN THE FOOD INDUSTRY	
APPLICATIONS	**CHALLENGES**
IMPROVEMENT OF TRACEABILITY Blockchain technology offers near-perfect traceability of the supply chain. This is especially important, since it affects aspects related not only to the quality and trust of consumers, but also to safety, public health, and the legal requirements.	**INTERNATIONAL STANDARDS** Need to define international standards on blockchain, which guarantee the interests of companies, and provide confidence in the verification mechanisms with this technology.
FIGHT AGAINST FRAUD Through blockchain technology, all members of the supply chain, from the producer to the consumer, can be guaranteed that, by scanning the QR codes on their labels, they can locate historical information and store all data on the origin, composition or quality of food in a reliable, fast and rigorous way.	**LEGAL REGULATION** New laws must be made to ensure that, through blockchain technology, companies, authorities, and consumers, are assured that food regulations are being followed. In addition, confidentiality, intellectual property and personal data must be protected.
COMPLIANCE WITH LEGISLATION Blockchain can facilitate compliance with regulations for companies, guaranteeing traceability, automating supply chain activities in a more efficient and transparent way.	**DIFFICULTY OF IMPLEMENTATION** Most of the producers tend to live in remote places or in underdeveloped countries and the application of this technology could be very complex or inaccessible for them.
ACCESS TO NEW MARKETS The blockchain has the power to promote entry to new digital markets, commonly called marketplaces, where agri-food producers will be able to communicate and share information directly with buyers.	**INTERACT WITH OTHER TECHNOLOGIES** Blockchain is nothing more than another technology, and its development will also depend on its ability to interact with other technologies such as IoT.
LOGISTICS AND EFFICIENT MANAGEMENT In the supply chain, the security of blockchain networks makes it possible to share information, manage financial flows and control logistics. Smart contracts can streamline management, reduce costs, and improve margins.	**IMPLEMENTATION COSTS** Costs of implementing the blockchain are another difficulty for companies, which will have to analyze the possibility that consumers are willing to pay more for the advantages it offers.
MARKETING Marketing managers of companies must consider new technologies when planning the marketing mix. This, will allow them to take full advantage of the competitive benefits that implementing blockchain technology can bring to their organization.	

Source: Own elaboration based on Dalmau (2021), Lage (2019), PIXELPLEX (2020), Suominen (2020), JUNIPER RESEARCH (2019), Fernández Esteban (2019), Kumar Sharma & Singh (2020), Gil & Cabrera (2020), Maestre (2019), Mena (2020)

4. SUCCESS STORIES

Many examples of companies, which are already successfully applying this technology at different stages of the supply chain have already been discussed when talking about blockchain applications in the agri-food sector.

However, detailing some particularly significant stories is considered interesting in order to complete the understanding of what this technology, even in development, can offer to the agri-food industry.

IBM FOOD TRUST

Firstly, and although it is not an agri-food company but a technological one, it is necessary to talk about one of the pioneering companies that have started offering blockchain solutions to their customers, in order to facilitate access to technology without the need to make costly investments to develop their own platforms.

In 2017, Walmart decided to improve the traceability of food sold in its supermarkets using blockchain technology. To achieve this, the firm partnered with IBM in order to implement the technology that would make it possible, thus, IBM Food Trust™, was born & trade; with Hyperledger Fabric-based technology in partnership with Ethereum. (DATTA, 2020)

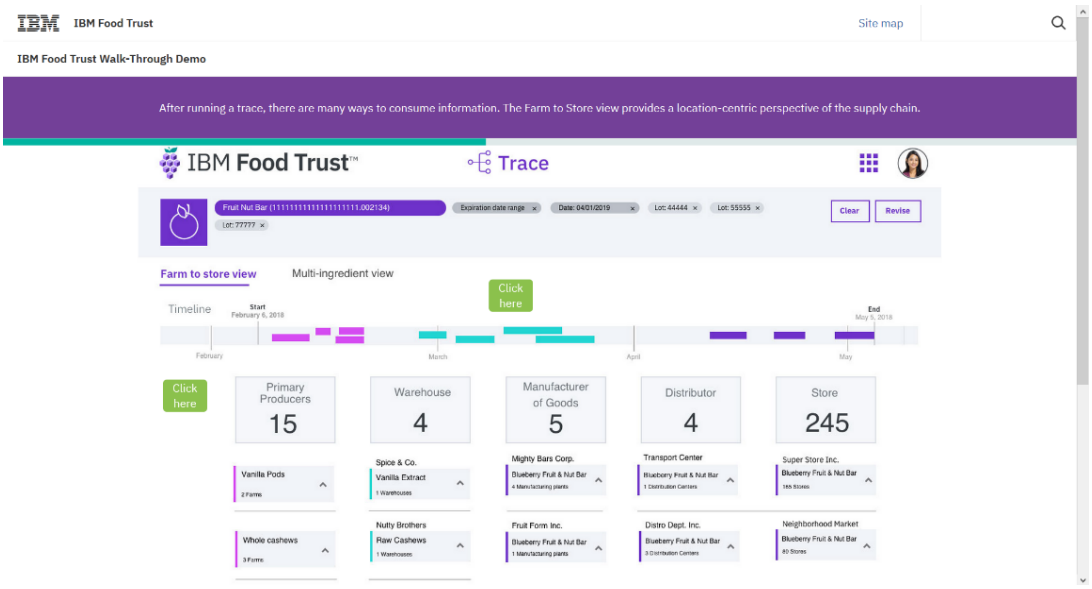
The IBM Food Trust™ network is based on blockchain technology, benefiting all participants by providing security, trust and digitization, which gives them greater efficiency in any segment of the supply chain. Nowadays it is defined as a collaborative network involving many other companies, producers, processors, wholesalers, manufacturers, distributors and retailers among others, which ensures transparency, safety and accountability throughout the food supply chain.

This network allows the exchange of food transactions information in a safe and reliable way, achieving a safer, smarter and more sustainable food ecosystem. Equally important is the reduction of waste and discarded food that is achieved thanks to the efficiency obtained by the blockchain in the management of the food chain. (IBM, 2021a)

The feature that really sets this network apart from others, is that it is the only one that allows all participants in the food supply to be connected at once, using a permanent, shared and with permits for all food system data. As a result, the safety and freshness of food is increased, it minimizes waste, and

provides greater supply chain efficiency, thus improving the reputation of the brand and contributing directly to the brand financial results. (see Figure 4.1)

Figure 4.1 Traceability management with IBM Food Trust ™



Source: IBM (2020)

In 2019, the IBM Food Trust™ network won the Spark Galleries Platinum Award in Digital and was considered as the fastest-changing company to change the world in that year. Also it won the 2019 Financial Times Intelligent Business Award. (IBM, 2021a)

WALMART

Walmart is a U.S. multinational dedicated to food distribution through more than 11,000 retail stores around the world. This company is constantly making improvements to its supply chain and it has pioneered introducing blockchain to improve the traceability of its products. (PIXELPLEX, 2020)

In 2016, Walmart observed traceability issues in detecting expiring products in its supermarkets, which made it necessary to withdraw large amounts of product with the consequent expense for the company and food waste. Before using the blockchain, they had tried many other systems without achieving complete success, since they were based on centralized databases. Chain managers saw in this technology the opportunity to achieve a transparent, decentralized supply chain with guarantees of immutability and trust. (PIXELPLEX, 2020)

Walmart began implementing this technology with the traceability of mango fruit from South America and sold in US stores and with pork sold in China. Both products had had some health problems in the past, and with traditional methods, it took up to 7 days to trace their origin. With the blockchain, it was possible to trace the origin of the products in a few seconds, with which, the objective sought by the company was achieved and also, the increase of consumer confidence. (DATTA, 2020)

Currently, the company applies the blockchain to the traceability of many other products, so that consumers can use their smartphone to scan a product QR code and obtain detailed information about the ingredients, origin, transportation, or any other information related to it. The firm has also begun to combine blockchain technology with other new technologies such as IoT (to record cold chain data, and other important parameters in the food chain) and Artificial Intelligence (AI) to predict retail consumption patterns or forecasting traffic on the roads. The applications are numerous and their implementation has only just begun. (PIXELPLEX, 2020)

CARREFOUR

Like Walmart in the United States, the European company Carrefour began to consider in 2017 the use of blockchain technology in order to make food traceability more transparent and regain consumer confidence, after several food scandals broke out in previous years. In March 2018, it launched Europe's first food blockchain applied to farm chicken from Auvergne in France, which allows the consumer, through a simple QR code, placed on the chicken packaging, to know all the details about the product from birth or feeding, to the slaughter, packaging and distribution of it. (ACTFORFOOD, 2021)

Also in Carrefour Spain, another project with blockchain was developed in 2018 in collaboration with the IBM Food Trust platform, to guarantee the traceability of the free-range chicken of the Galician company Coren, raised without antibiotics, which was the first blockchain traceability system in the food chain implemented in Spain. (see Figure 4.2) (ITUSER, 2018)

Figure 4.2 Blockchain traceability in Coren chicken

Source: ITUSER (2018)

The company has been incorporating the blockchain into the traceability of many other products since then, and expects that in 2022 it will be operational in Carrefour's 100 Quality and Origin divisions.

CAMPOFRÍO-NAVIDUL

The famous Spanish firm Navidul, the brand of Iberian ham from Campofrío (participant of the SIGMA group in Europe) has decided to incorporate blockchain technology in its Iberian ham and shoulder products, in order to satisfy and provide greater confidence to its customers. For this, they have developed a blockchain solution with the support of Deloitte and Alastria. (Blázquez, 2020)

For achieve that, the company will incorporate this technology in its Iberian products during this year 2021 through the use of QR codes, in this way, when buying the final product, the consumer could obtain the answers to questions such as what has been the feeding of the pig, the total weight, where it has been cured or the date of preferential consumption. The QR code is printed on the label that is placed on the ham band. (see Figure 4.3)

Figure 4.3 Blockchain in Navidul Iberian ham. Tagged with QR code

Source: REVISTA ALIMENTARIA (2020)

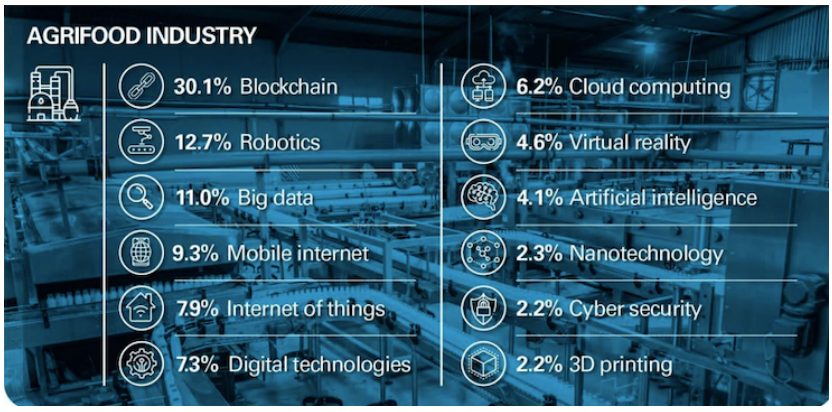
In the words of the Director of the Navidul Business Unit, Manso, the application of this technology will allow customers and consumers to know all the information about the life cycle of hams and shoulders, with the maximum guarantees of quality and food safety. In addition, the firm hopes to get the blockchain to guarantee greater transparency, since it will allow them to share the information of all the stages of production, distribution and transformation of the products with the suppliers, clients and consumers. (REVISTA ALIMENTARIA, 2020).

5. EMPIRICAL STUDY

Despite the growing interest shown by the proliferation of events, conferences and courses on the blockchain topic, statistical information about the degree of adoption of digital technologies in the Agri-food Sector is very limited. The "Survey on the use of information and communication technologies (ICT) and electronic commerce in companies" prepared by INE (2020) does not provide information about the Primary Sector. In this regard, CaixaBank Research published in October 2020 an analysis on the degree of popularity of new digital technologies in the Agri-Food Sector using the information provided by TWITTER. (Montoriol-Garriga,2020).

According to this report, "The blockchain is the technology that stands out the most in the agri-food industry (30% of all tweets about digitization in the sector)." (Montoriol-Garriga, 2020, p.9), it is confirmed once again the relevance of this technology for this sector, by allowing the traceability of all links in the food chain to be controlled digitally to provide security to the growing concerns of consumers in aspects such as transparency about origin, product quality and food safety (see Figure 5.1).

Figure 5.1 Number of tweets of a technology out of the total of tweets related to the digitization of the sector



Source: Montoriol.Garriga (2020) CaixaBank Research

With the empirical study carried out in this project, it is intended to make an approximation to the degree of knowledge of blockchain technology that the agri-food industry of Castilla y León has. To determine this, a survey was carried out (Appendix 1 and 2), that was sent to more than 200 companies in the sector via email, getting 48 responses -24% response rate-. As reflected in the *Technical sheet of the investigation* (see Table 5.1), the sampling procedure is based on sending the survey to companies from all agri-food sectors and billing ranges. In the survey, which is answered anonymously, a question has been included to determine its size, as well as a question about the sector which they belong to, in order to obtain information on what type of companies show the most interest in the blockchain technology.

Table 5.1 Technical sheet of the investigation and description of the samples

Universe	Agri-food sector companies
Sampling procedure	Includes all agri-food sectors, billing ranges and digitalization degrees
Information gathering	Google Forms online survey, via e-mail
Scope	Castilla y León (Spain)
Sample	48 companies
Date of fieldwork	From February 15 to May 15, 2021
CHARACTERISTICS OF THE COMPANIES SAMPLE	
Size	Less than 500.000 euros (31,3%); from 0.5 to 1 million euros (10,4%); from 1 to 5 million euros (33,3%); from 5 to 20 million euros (12,5%); from 20 to 100 million euros (4,2%); more than 100 million euros (8,3%)
Sector in which they belong to	Beverages (43,8%); Meat industries (10,4%); Dairy products (4,2%); Fruits and vegetables (4,2%); Wine; Honey; Agriculture...
Degree of digitalization (1-little;5-a lot)	Level 1 (4,2%); Level 2 (12,5%); Level 3 (60,4%); Level 4 (20,8%); Level 5 (2,1%)

Source: Own elaboration

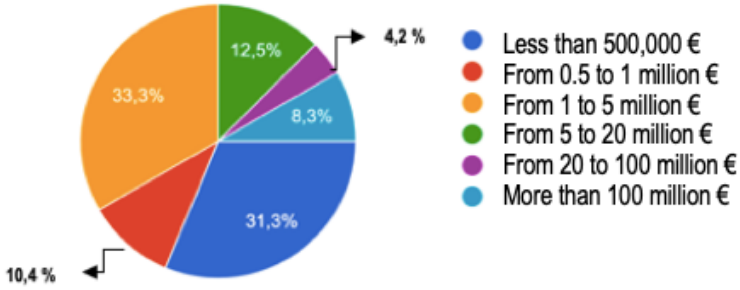
The emails of the companies have been obtained thanks to the collaboration of the *Servicio Territorial de Agricultura, Ganadería y Desarrollo Rural de la Junta de Castilla y León de Burgos.* The sample has been completed by consulting the corporate web pages of companies from all agri-food sectors of Castilla y León, in order to make it as complete as possible.

5.1. RESULTS

The results obtained from the survey can be consulted in their entirety in Appendix 1 and 2 of this Bachelor Thesis, available at the end of the document, in order to gain a better understanding of this empirical study. They are quite varied, since the 48 responses obtained come from companies from almost all sectors of the agri-food industry in Castilla y León and it includes from SMEs to large companies.

Regarding the size of the companies, most of them had a turnover of less than 5 million euros (75%), but the percentage of large corporations with a turnover greater than 100 million euros (8.3%) is also included (see Figure 5.2)

Figure 5.2 Which of the following options best represents your company's turnover in 2020?



Source: Own elaboration

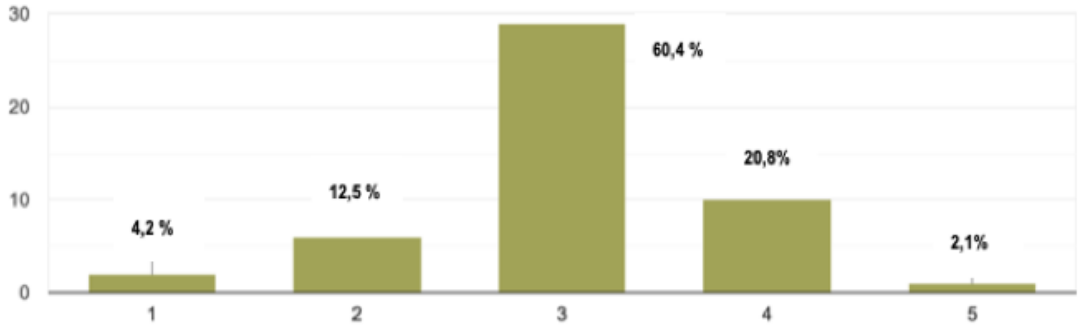
Differentiating by sectors, the most numerous is *Beverages* (43,8%). The percentage of *meat industries* is also significant (10,4%). The rest of industrial sectors are all represented, except the *Bakery and food pastes and Oils and fats* one. Furthermore, it is highlighted that, responses from the primary sector are included (Agriculture and Livestock), and other activities such as *wine tourism, honey* and *agricultural machinery.* (see Figure 5.3)

Figure 5.3 What sector does the company where you work belong to?

Source: Own elaboration

Regarding the degree of digitization of companies in Castilla y León (see Figure 5.4), 83.3% of those surveyed have a medium or high degree of digitization. Almost half of the participants (47.9%), mainly use *Mobile Internet*. In none of the cases the blockchain appears as the technology used as a priority. Other of the most used technologies are *Cloud Internet* (22.9%), *Digital technologies* (20.8%), cybersecurity (4.2%) or Internet of Things (4.2%).

Figure 5.4 What is the degree of digitalization of your organization? (1 not at all -5 a lot)



Source: Own elaboration

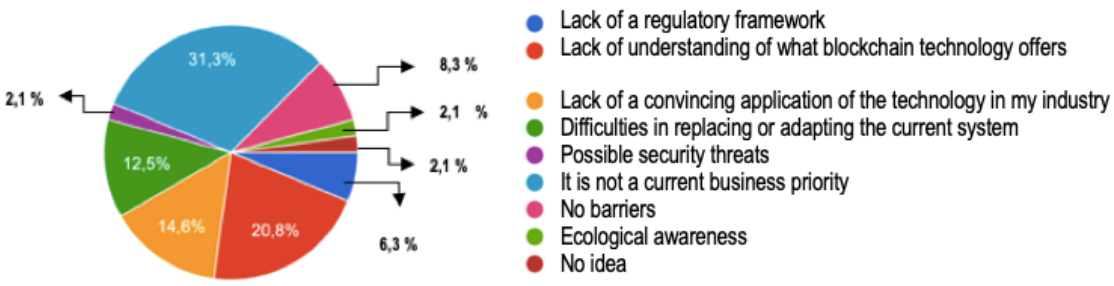
Most of the companies surveyed, 52.1%, have heard of blockchain technology. However, when analyzing the answers given to the question: *In case you heard of blockchain technology, how would you define it?* it has been found that none of the respondents has very clear about the full potential that this technology has. It should be noted, however, that in many of the answers concepts associated with the use of the blockchain are repeated, like for instance: “Improved traceability “,”Theoretically very safe and

energy intensive", *"as the elimination of intermediaries", "The trust machine", "A system that allows the exchange of information in a more secure way", "Secure databases for internet transactions",* etc.

58.3% of the firms say they believe that this technology could be useful for their company in the future, although, 31.2% admit they are unaware of the advantages of blockchain over other technologies. Regarding the possible benefits that its use could bring, 45% think it would improve traceability, other answers mention trust, differentiation from competitors, transparency, automation, cost reduction and elimination of intermediaries.

On the main barriers that those firms have in order to invest in this technology (see Figure 5.5), 31.3% *do not consider it a current business priority*, also they affirm that it is due to *a lack of understanding of what blockchain technology offers*, answered by 20.8%. *The lack of a regulatory framework, the lack of a convincing application, difficulties in replacing or adapting the current system* and *potential security threats* are other answers. Particularly striking is *the ecological awareness* response, which may be related to one of the blockchain definitions provided by the respondents, in which it is stated that the blockchain is a technology that consumes a large amount of energy.

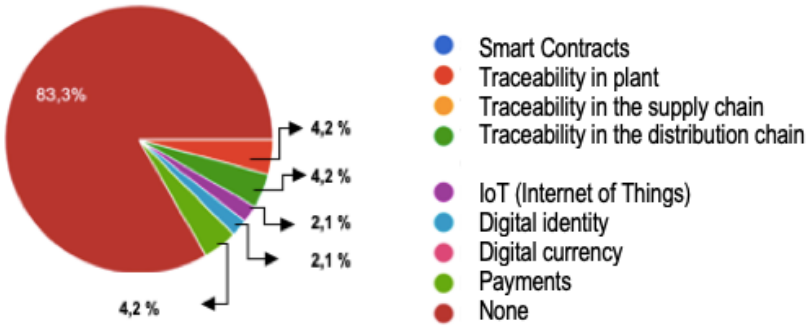
Figure 5.5 What are your organization's barriers, if any, to investing in blockchain technology?



Source: Own elaboration

The use of the blockchain by the companies surveyed is still very limited. A large majority of companies (83.3%) *do not use it* yet. 8.4% use it to *guarantee traceability in plant* or *in the distribution chain*, 4.2% *to make payments, IoT* (2.1%) or *digital identity* (2%). (see Figure 5.6)

Figure 5.6 Does your company work with blockchain for any of these uses?

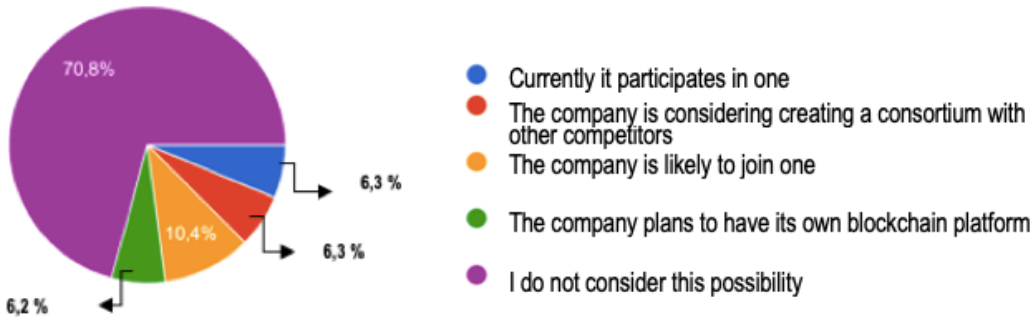


Source: Own elaboration

In addition to the aforementioned barriers, the little implementation of the blockchain may be related to the fact that only 37.5% consider that it is more safe than other more conventional information technologies.

The possibility of collaboration of the company in a blockchain consortium with competitors goes in relation to the previous answers, since 70.8% do not contemplate it. However, of the interested companies, 16.7% already participate in one or are considering forming one, 6.3% consider the idea of joining one and 6.2% prefer to have their own blockchain platform. (see Figure 5.7)

Figure 5.7 What position does your company have on the possibility of participation in a blockchain consortium with competitors?

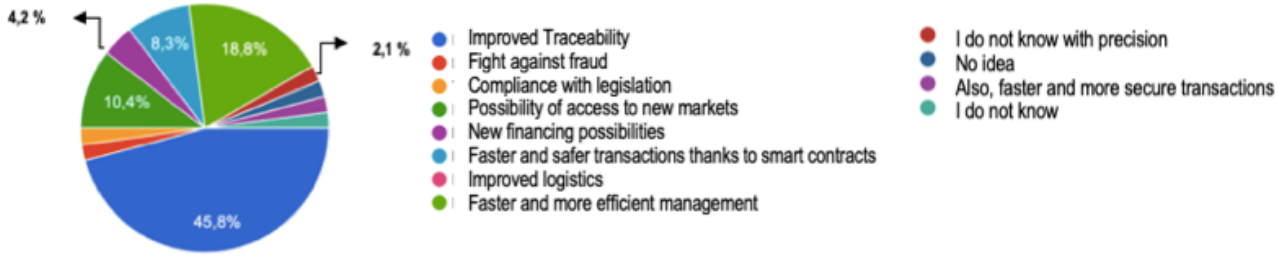


Source: Own elaboration

Stakeholders interested in the company's blockchain strategy are mostly *partners* (16.7%) and *market analysts* (8.3%), and only 6.3% have pointed to *customers* and 2.1% to *suppliers*.

Finally, the applications that respondents consider the most interesting in the food sector are: *the improvement of traceability* with 45.8%, *the fastest and most efficient management* (18.8%), *the possibility of accessing new markets* (10.4%) and *faster and safer transactions thanks to smart contracts* (8.3%). Other applications mentioned are *the new financing possibilities*, *the fight against fraud, compliance with legislation* and *the possibility of making faster and secure transactions.* (see Figure 5.8)

Figure 5.8 In your opinion, what specific applications of the blockchain can be the most interesting in the food sector?



Source: Own elaboration

6. CONCLUSIONS

With the completion of this Bachelor Thesis about Blockchain Applications in Food Marketing, it was intended to get an approach to the general fundamentals of blockchain technology and to know its profits beyond the world of digital currencies or cryptocurrencies. Especially, it was about studying its possible applications in food marketing and detailing some success stories in companies in the agri-food sector, as well as carrying out an empirical study that would allow to determine the degree of knowledge and implementation of the blockchain in food companies in Castilla y León.

Regarding the first objective of this work, *to know about blockchain technology*, it has been possible to make an orderly summary of the enormous amount of information that exists on this topic, therefore it can be understood by the general public, without the need of special technical knowledge. Review of applications in different sectors (such as logistics, tourism, energy, insurance or health), has provided an

idea about the growing introduction of this technology in all areas in recent years, and also, its huge acceptance by both large corporations and government organizations and all types of companies.

The second goal, *to study its applications in the agri-food sector,* has shown that the blockchain can serve to improve such important aspects as the supply chain, traceability, the fight against fraud, compliance with legislation and most importantly, to guarantee the safety of the food we consume due to the possibility of being able to withdraw possible defective batches in record time. Many examples have been related where companies such as IBM, Walmart, Carrefour or Navidul, are already using blockchain successfully, and it can be concluded that the development of specific applications has only just begun.

The third and last objective, *to conduct an empirical study to compare primary with secondary information,* has allowed to know the interest that companies in Castilla y León have in this technology, with an unequal degree of knowledge of it, and some developments already implemented in a few but significant companies. The answers obtained have revealed many aspects that, previously, has been mentioned in this Bachelor Thesis.

The importance of digital transformation for the competitiveness of companies, which has become especially evident in the current pandemic (Montoriol-Garriga, 2020), is reflected in the high degree of digitization and in the interest shown by respondents in this technology.

Regarding the blockchain applications that respondents consider most interesting for the food sector, most opt for traceability, smart contracts, the possibility of access to new markets or efficiency. As Fonts (2018) reflected, with the implementation of the blockchain technology, companies will be able to reduce the huge problem of food safety by improving traceability, transparency and trust. However, few companies are aware of the importance that -according to the study carried out by JUNIPER RESEARCH (2019)-, this technology may have in the fight against fraud and counterfeits.

Related to difficulties that the surveyed companies would have to implement this technology, most confess that it is not a priority for them, or the lack of knowledge of the technology or its applications, but some are also concerned about legislation, security, and other technical issues. All these disadvantages coincide with those detailed by Mena Duran in her article *El Blockchain y la trazabilidad alimentaria* (Mena, 2020), discussed in previous chapters of this Bachelor Thesis.

In this sense, it should be noted that, one of the main limitations when conducting the empirical study has been the difficulty in getting answers from the companies that have been contacted through the addresses obtained from their web pages. Without the support of the *Servicio Territorial de Agricultura, Ganadería y Desarrollo Rural de la Junta de Castilla y León de Burgos*, it would not have been possible to obtain these results, which, although they are only from 48 companies, they are considered relevant because they represent multiple sectors, and both SMEs and large companies and the blockchain implementation is at early stages. As possible future developments, it would be interesting to expand the number of companies to be surveyed contacting other associations and organizations that encourage them to collaborate with future studies.

Finally, as a personal point of view, having done this Bachelor Thesis has allowed me to know and value the blockchain, but also be aware that, as any new technology, its implementation implies risks that must be assessed by companies. With this project I hope to have provided a complete and easy-to-read summary, that allows an approach vision to *Blockchain Applications in Food Marketing*. I also consider that the results of the survey conducted, and the success stories analyzed, could encourage companies interested in this technology, to implement it, following the examples of pioneering companies in Castilla y León.

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APPENDIX 1. SURVEY RESULTS

Appendix 1

SURVEY

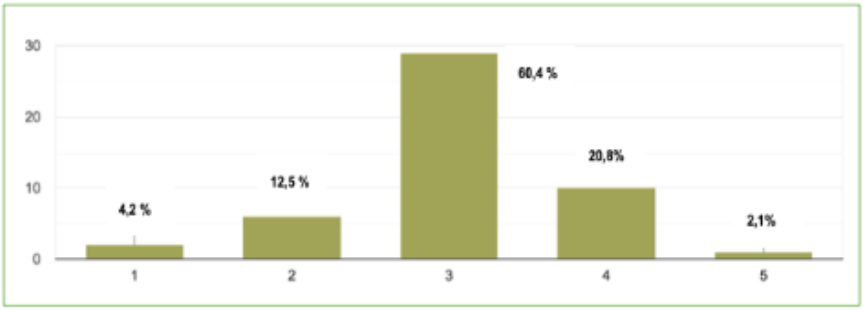
BLOCKCHAIN IN THE FOOD INDUSTRY

Bachelor Thesis, University of Burgos, Consolación Gómez González 2021

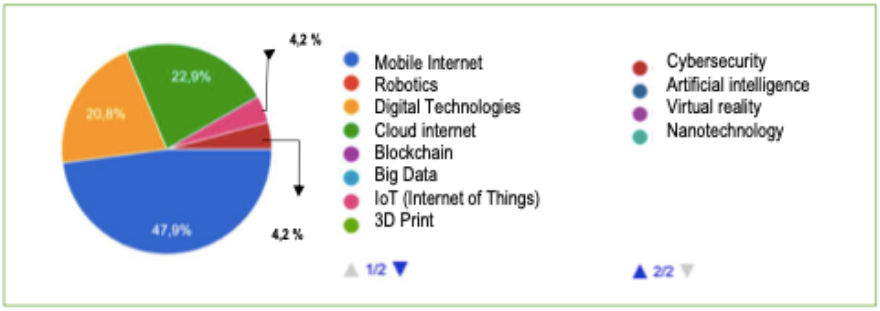
1

Appendix 1

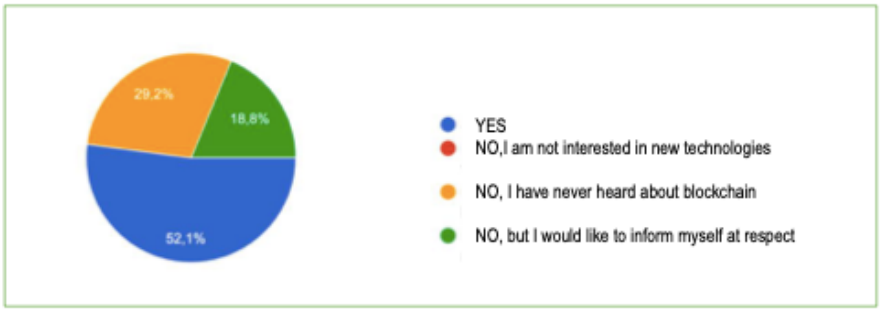
⇒ ***From 1 to 5 What is the degree of digitization of your organization?*** *48 responses*



⇒ ***What digital technology do you mainly use?*** *48 responses*



⇒ ***Have you heard about blockchain technology?*** *48 responses*



2

Appendix 1

⇒ ***In case you YES heard of blockchain technology, how would you define it?*** *23 responses*

I've only heard about it, I'm not too clear about what it is

They have explained to us that it is a value chain applied to the data, as if they were currencies and that it guarantees more security in the processes because everything is fragmented

I don't have enough knowledge to give an opinion

Guarantees the unique traceability of a product, any change modifies the chain

Theoretically very safe and energy intensive

As the right digital technology to demonstrate product traceability.

System that provides security to internet operations

Improved traceability

Safe and inviolable technology in financial transactions

Little clarifying

Cloudy, uncertain and related to Bitcoin and mining that nobody understands

Encryption algorithm that guarantees non-repudiation.

as the elimination of intermediaries

A system that allows the exchange of information in a more secure way

A safe way to record moves

A good tool difficult to understand a priori but with many utilities.

Block technology

The trust machine

Safe

The verification of the network in continuous change and evolution, generating records until the end of the life of a product.

The validation by users of computer topics

Secure databases for internet transactions

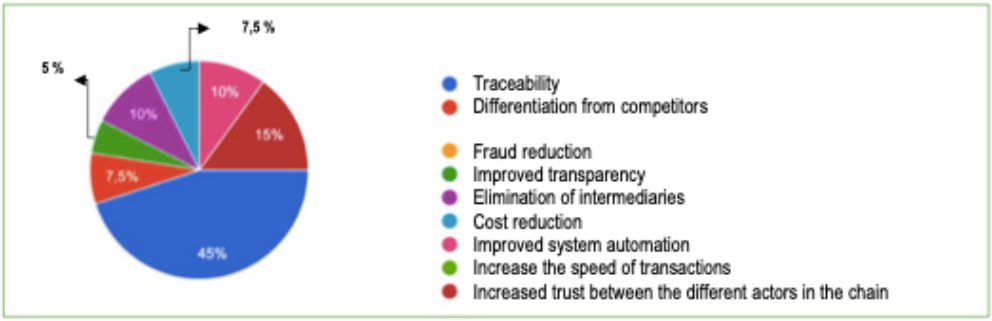
I have not heard

3

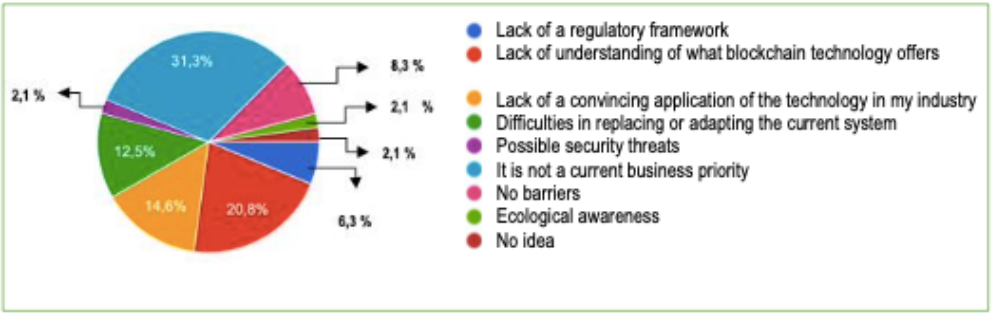
Appendix 1

⇒ ***Blockchain is the technology that has made cryptocurrencies like Bitcoin possible. This technology allows you to create databases and carry out transactions safely through the use of cryptography, without intermediaries, providing security, transparency and efficiency. If your company still does not work with blockchain technologies, do you think it could be useful for your company in the future?*** *48 responses*

⇒ ***In case you consider that the Blockchain could be useful for your company in the future, what is the benefit it brings or could bring to your company?*** *40 responses*



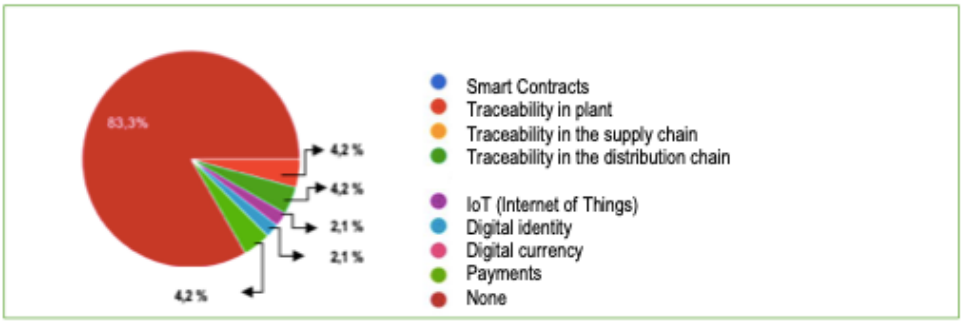
⇒ ***What are your organization's barriers, if any, to investing in blockchain technology?*** *48 responses*



4

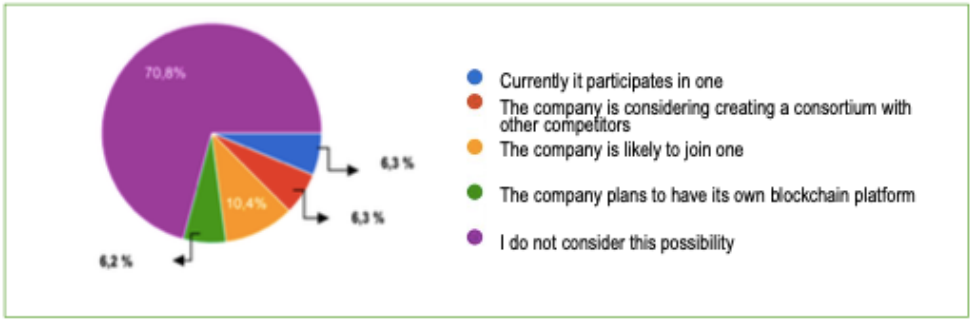
Appendix 1

⇒ ***Does your company work with blockchain for any of these uses?*** *48 responses*



⇒ ***Do you think that a solution based on blockchain is currently more secure or less secure than those currently used from more conventional information technologies?*** *48 responses*

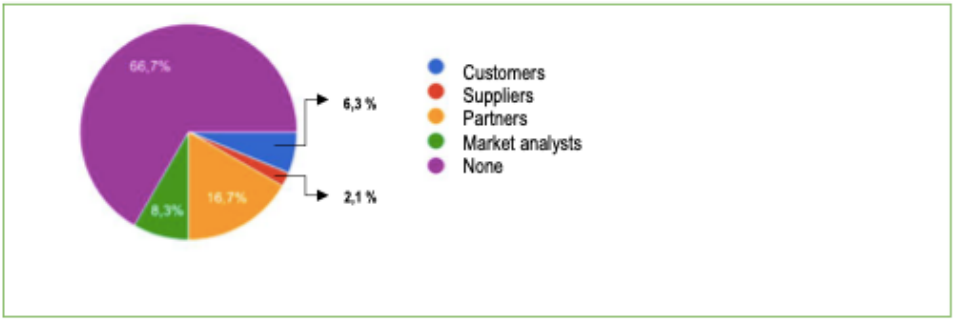
⇒ ***What position does your company have on the possibility of participation in a blockchain consortium with the competition?*** *48 responses*



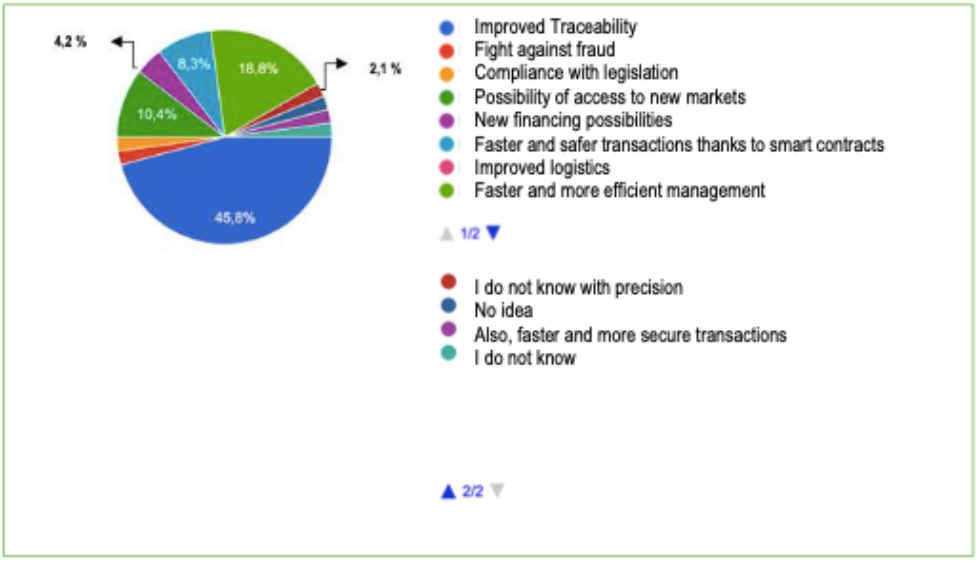
5

Appendix 1

⇒ ***Which stakeholders in your company have shown interest in the company's blockchain strategy?*** *48 responses*



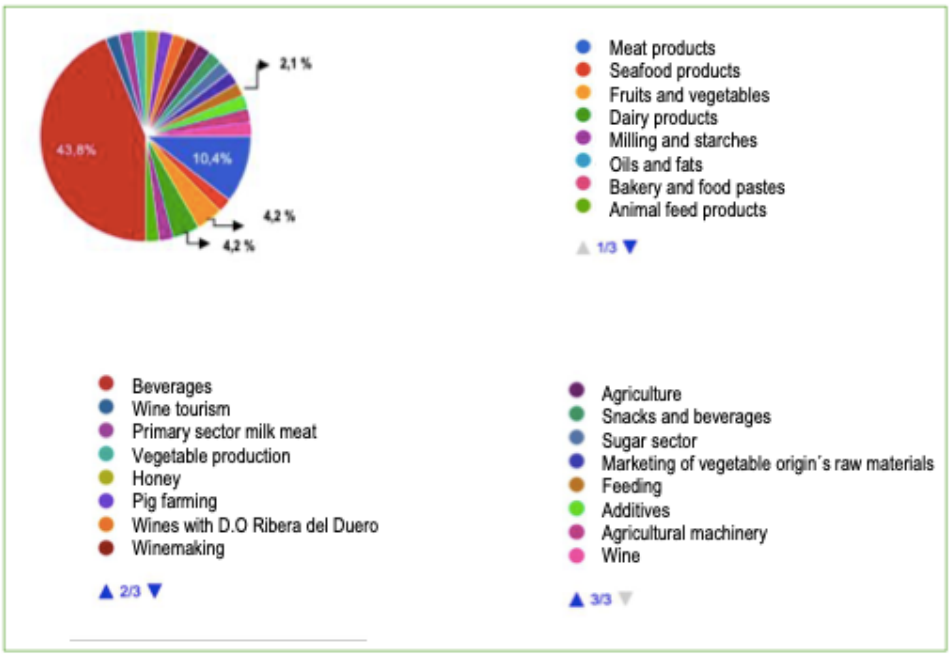
⇒ ***In your opinion, what specific applications of the Blockchain can be the most interesting in the food sector?*** *48 responses*



Appendix 1

⇒ ***Which of the following options best represents your company's turnover in 2020?*** *48 responses*

⇒ ***What sector does your company belong to?*** *48 responses*



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APPENDIX 2. QR CODE SURVEY RESULTS