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BLOCKCHAIN FOR “MADE IN ITALY” EXTRA VIRGIN OLIVE OIL:

A TOOL FOR THE PROTECTION OF ITALIAN PRODUCERS

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To my grandfather Elio, forever.

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Acronyms And Abbreviations

BCT	Blockchain Technology
BINT	Behavioral Intention to Adopt
DLT	Distributed Ledger Technologies
DPI	Department Of Primary Industry
EC	European Commission
EU	European Union
EXP	Effort Expectancy
EVO	Extra Virgin Olive Oil
FCON	Facilitating Conditions
GOD	Great Organized Distribution
IPFS	Interplanetary File System
ISMEA	Istituto Servizi Mercato Agricolo Alimentare
NAOOA	North America Olive Oil Association
NTF	Non-Fungible Token
PEXP	Performance Expectancy
PI	Personal Innovativeness
PLS-SEM	Partial Least Squares Structural Equation Modeling
REG	Regulation
SINF	Social Influence
TRUS	Trust
UNDP	United Nations Development Programme
UTAUT	Unified Theory of Acceptance and Use of Technology
WTPQ	Willingness to pay

Abstract

Il presente lavoro approfondisce le potenzialità e le possibilità di impiego della tecnologia blockchain, come strumento per la tutela del marchio "Made in Italy". Il focus, in questo lavoro, è il suo utilizzo da parte dei produttori italiani per la tutela di una delle eccellenze del nostro territorio, l'olio extra vergine di oliva. Questa tecnologia, per sua propria natura, risulta essere promettente nel tutelare in generale le produzioni, in particolare quelle legate all'agri-food, in quanto consente di raccogliere e immagazzinare informazioni relative a tutta la supply chain, mettendole in sicurezza da possibili tentativi di manomissione.

Sulla base della recente legge italiana relativa alla tutela del marchio "Made in Italy", comprendente diversi settori produttivi, il settore dell'agri-food trova per forza spazio, soprattutto con un prodotto come l'olio extra vergine di oliva. Esso, infatti, data la sua grande rinomanza in tutto il mondo, è spesso soggetto a fenomeni di contraffazione. L'obiettivo di questo lavoro è prima di tutto approfondire il settore dell'olio di oliva, l'importanza che riveste in Europa, ma soprattutto in Italia, dopodiché la possibilità di adozione della blockchain come tecnologia per la tracciabilità dell'olio, andando ad analizzare dal punto di vista dei produttori, l'intenzione nell'adottarla e la disponibilità a pagare per questo servizio. I risultati ottenuti sono significativi. Sebbene la conoscenza della blockchain non sia così diffusa tra i produttori di olio di oliva, risulta che nel momento in cui si comprende le sue potenzialità, essi siano intenzionati ad approfondire le sue possibili applicazioni. Un aspetto da notare è che attualmente, per i produttori, nonostante i benefici che questa tecnologia possa portare, essi non siano disposti a pagare le cifre relative alla fruizione del servizio. Ma aspetto ancora più degno di nota, sembra che il primo motivo che limita l'adozione di questa tecnologia, sia l'incertezza nelle capacità dei produttori nel saperla utilizzare. Quindi da un lato i risultati ottenuti sono promettenti, dimostrando che la natura di questa tecnologia non crea insicurezza, ma anzi riceva fiducia da parte dei produttori, ma al tempo stesso la poca conoscenza e l'insicurezza nell'approcciarsi a queste nuove tecnologie ne limita la diffusione. Risulta essere quindi fondamentale divulgare informazioni sulle potenzialità che la blockchain possiede, soprattutto tra i produttori, e guidarli nel suo utilizzo, per consentire una sua più rapida diffusione e tutelare uno dei settori di punta del nostro territorio.

Introduction And Aim Of The Thesis

In Europe and Italy, the olive oil's sector represents an important part of the agricultural production's value, especially for the extra virgin olive oil. The Italian olive oil is globally renowned for its quality, authenticity and unique production methods. But for these reasons and his prestige, it has attracted phenomena such as counterfeiting and food frauds. These include actions like the falsification of the origin, the selling of seed oil mixed with olive oil and sold as EVO, the addition of carotenoids and chlorophyll or the falsification of quality marks. As consequence, the reputation of the Italian olive oil producers is being threatened and consumer trust is compromised, so the protection of the "Made in Italy" label in this sector has become crucial.

Blockchain technology, firstly developed for the Bitcoin, with its decentralized, transparent, and tamper-resistant properties, represents a promising solution also to trace the supply chain in the agri-food sector, ensuring authenticity and enabling consumers to verify product origins with confidence.

Considering all of this, this study aims to explore the potential use of the blockchain system as a tool for the protection of the Italian producers of olive oil, by ensuring traceability, authenticity and transparency across the supply chain. By investigating how this tool can safeguard the "Made in Italy" label preventing counterfeiting, this study seeks to provide practical insights into how the technology can be integrated within the olive oil sector, supporting the value of Italian craftsmanship and reinforce consumer trust.

Therefore, the main objectives of this thesis are: understand of the blockchain's technology and its application for the traceability of agri-food products, especially the extra virgin olive oil; investigate producers' knowledge about this system and the factors that affect the intention in adopting it; estimate producers' willingness to pay for this technology.

In details this work shows as first chapter a short introduction, with the definition of the olive oil, its characteristics and its supply chain, with the European and Italian framework and the main types of olive oil available on the market. In the second chapter the dynamics of the olive oil's marketplace are described, both at European and national level. The third chapter describes the application of the blockchain in the agri-food sector with the methodologies applied for the analysis. This study is based on an online survey, spread throughout the olive oil's producers in Italy, that allows to get data related to the intention to adopt the blockchain technology and the willingness to pay for it. These data are collected, analyzed and then processed. After this the description of the model applied, used for the statistical analysis is carried out. In the fourth chapter the results are present and discussed, with a first socio-demographic description of the sample, followed by descriptive statistic. The fifth chapter is about the case study, with the description of a company that produces olive oil, located in the Marche region, which wants to adopt the blockchain technology for the traceability of its extra virgin olive oil. After this, the final considerations are outlined.

CHAPTER 1
THE OLIVE OIL'S SUPPLY CHAIN: DEFINITION, CHARACTERISTICS AND REGULATORY FRAMEWORK

1.1 **Olive oil: definitions and characteristics**

Olive oil is a liquid fat obtained by pressing whole olives, the fruit of *Olea europaea*, which is a traditional tree crop of the Mediterranean Basin.

The Reg. (UE) 1308/2013 states that "Virgin olive oils" mean oils obtained from fruit of the olive tree solely by mechanical or other physical means under conditions that do not lead to alterations in the oil, which have not undergone any treatment other than washing, decantation, centrifugation or filtration. Virgin olive oils are exclusively classified and described as follows:

a) "*Extra virgin olive oil*" means virgin olive oil having a maximum free acidity, in terms of oleic acid, of 0.8 g per 100 g.
b) "*Virgin olive oil*" means virgin olive oil having a maximum free acidity, in terms of oleic acid, of 2 g per 100 g.
c) "*Lampante olive oil*" means virgin olive oil having a free acidity, in terms of oleic acid, of more than 2 g per 100 g.

The other typologies of oils, obtained applying one or more of the processes not allowed for the virgin olive oil, are classified as follows:

I. "*Refined olive oil*", obtained by refining virgin olive oil with an acidity content not more than 0.3 g per 100 g.
II. "*Olive oils composed of refined olive oils and virgin olive oils*" means olive oil obtained by blending refined olive oil and virgin olive oil (other than "lampante" olive oil), with acidity not more than 1 g per 100 g.
III. "*Crude olive-pomace oil*" means oil obtained from olive pomace by treatment with solvents or by physical means or oil corresponding to "lampante" olive oil.

IV. "*Refined olive-pomace oil*" means oil obtained by refining crude olive-pomace oil, having free acidity content of not more than 0.3 g per 100 g.

V. "*Olive-pomace oil*" means oil obtained by blending refined olive-pomace oil and virgin olive oil other than lampante olive oil, having a free acidity content of not more than 1 g per 100 g (Union, 2013).

Different types of olive oils mean different quality levels, as shown in Figure 1-1.

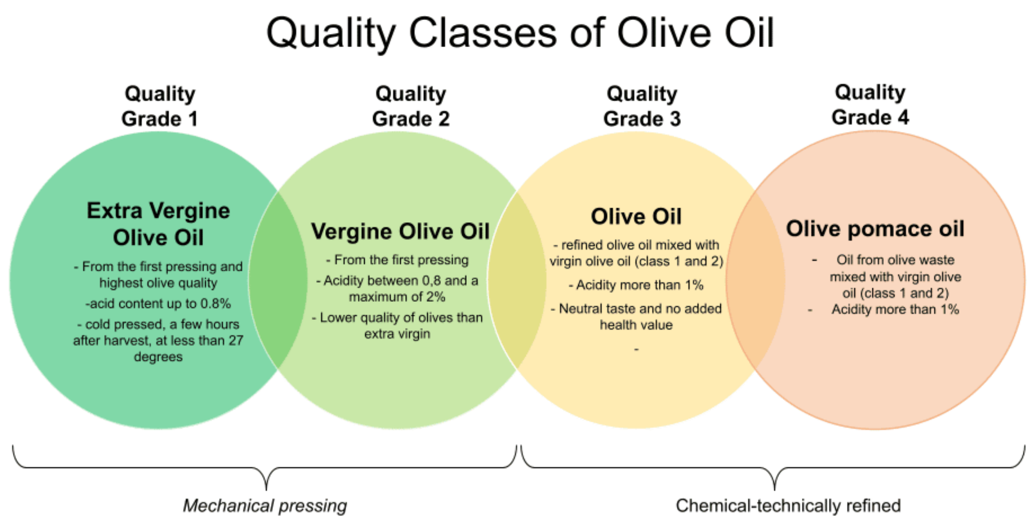

Figure 1-1: Quality classes of olive oil (ilcircolo.eu)

The most important components in olive oil are fatty acids. Olive oil consists mainly of oleic acid (up to 83%) with smaller amounts of other fatty acids, including linoleic (up to 21%) and palmitic (up to 20%) acids. There are only a few types of fatty acids in olive oil, but the proportions of them strongly influence the characteristics and nutritive value of the oil. In a molecule of oil, the fatty acids are bound in groups of three together with a unit of glycerol. These units are called triacylglycerol molecules or TAGs. The glycerol unit can have any three of several fatty acids attached to form TAGs. The carbon chains may be differ in length and they may be saturated, monounsaturated or polyunsaturated. It is the relative proportion of these that makes one oil different from another. About 95–98% of olive oil consists of TAGs. The remaining part of the oil, although only a small part in proportion to TAGs, includes a very large number of minor compounds, including the phenolics and the sterols. In refined oil, many of these minor components are removed. Phenolics represent a large and varied group of compounds. In olive oil they play a major role as antioxidants, contributing to oil color and to the bitterness. Many phenolics are water soluble, and therefore the quantity of these compounds in olive oil may depend on the extraction process. Olive oil is often analyzed for the phenolic content to help determine the flavor and/or storage characteristics of the oil. Sterols are another large group of components with nutritional benefits for consumers. Researchers have recently recognized the benefits of phytosterol in human health (DPI, 2006).

Other minor components that contribute to olive oil characteristics are:

- Hydrocarbons, such as squalene and ß- carotene which adds color to the oil and acts as an antioxidant during storage
- Tocopherols, which are also antioxidants – including vitamin E
- Fatty alcools
- Waxes, low in virgin olive oil but they are present in high quantities in solvent extracted oil
- Pigments (chlorophyll, carotenoids). Chlorophyll gives the characteristic green color to olive oil. It is a photosensitizer and contributes toward photo-oxidation of the oil
- Volatile components, which give the oil its odor and contribute to the flavor. These include aldehydes, ketones, thiols, alcohols and acids (DPI, 2006).

1.2 **The supply chain**

Olive oil extraction is the process of extracting the olive oil present in the drupes. Olive oil is produced in the mesocarp cells and stored in a particular type of vacuole called lipo vacuole. Olive oil extraction is the process of separating the oil from the other fruit contents (vegetative extract liquid and solid material) by mechanical or chemical means. Green olives usually produce more bitter oil, and overripe olives can produce oil with fermentation defects; so, for good olive oil, care is fundamental to make sure the olives are perfectly ripened.

The extraction process is generally as follows: after the steps related to the agricultural aspects, the first operation when extracting olive oil is washing the olives, to reduce the presence of contaminants, especially soil, which can create a particular flavour effect called "soil taste". Then, the olives are ground into paste using large millstones (traditional method), hammer, blade, or disk mill (modern method). If ground with millstones, the olive paste generally stays under the stones for 30 to 40 minutes. A shorter grinding process may result in a paste that produces less oil and has a less ripe taste; a longer process may increase oxidation of the paste and reduce the flavour. After grinding, the olive paste is spread on fibre disks, which are stacked on top of each other in a column, then placed into the press. Pressure is then applied onto the column to separate the vegetal liquid from the paste. This liquid still contains a significant amount of water. Traditionally, the oil is separated from the water by gravity. This very slow separation process has been replaced by centrifugation, which is much faster and more thorough. The centrifuges have one exit for the (heavier) watery part and one for the oil. Olive oil should not contain significant traces of vegetal water as this accelerates the process of organic degeneration by microorganisms. Modern grinders reduce the olives to paste in seconds. After grinding, the paste is stirred slowly for another 20 to 30 minutes in a particular container (malaxation process), where the microscopic oil drops aggregate into bigger drops, which facilitates the mechanical extraction. The aromas are created in these two steps through the action of fruit enzymes. Afterwards, the paste is pumped into an industrial decanter where the phases will be separated. Water is added to facilitate the extraction process with the paste. The decanter is a large capacity horizontal centrifuge rotating approximately at 3,000 rpm. This high centrifugal force created allows the phases to be readily separated according to their different densities (solids > vegetation water > oil). Inside the decanter's rotating conical drum there is a coil that rotates more slowly, pushing the solid materials out of the system. The separated oil and vegetation water are then rerun through a vertical centrifuge, working around 6,000 rpm, that will separate the small quantity of vegetation water still contained in oil and vice versa. With the *three phases* oil decanter, a portion of the oil polyphenols is washed out due to the higher quantity of added water (when compared to the traditional method), producing a larger quantity of vegetation water that needs to be processed. Instead, the *two phases* oil decanter was created as an attempt to solve these problems. Sacrificing part of its extraction capability, it uses less added water thus reducing the phenol washing. This type of decanter, instead of having three exits (oil, water, and solids), has only two. Thus, olive paste is separated into two phases: oil and wet pomace. The water is expelled by the decanter coil together with the pomace, resulting in a wetter pomace that is much harder to process industrially. The energy costs of drying the pomace for the hexane oil extraction often make the extraction process sub-economical. In practice, then, the two phases decanter solves the phenol washing problem but increases the residue management problem. This residue management problem has been reduced by the collection of this wetter pomace, which is transported to specialized facilities called extractors which heat the pomace between 45 °C and 50 °C and can extract up to a further 2 litres per 100 kilos of pomace using adapted twophase decanters. The *two-and-a-half-phase* oil decanter is a compromise between the two previous types of decanters. It separates the olive paste into the standard three phases but has a smaller need for added water and a smaller vegetation water output. Therefore, the water content of the obtained pomace comes very close to that of the standard three-phase decanter, and the vegetation water output is relatively small, minimizing the residue management issues. Depending on the olives and processing, the decanter or tricanter can extract between 85% and 90% of the olive oil in the 1st extraction. The yield from olive oil manufacture can be increased even further with a 2nd extraction. The olive oil yield increases to as much as 96% by combining the 1st and 2nd extractions (Flottweg, 2024).

The oil produced by only physical (mechanical) means as described above is called virgin oil. Sometimes, the produced oil will be filtered to eliminate remaining solid particles that may reduce the shelf life of the product. Labels may indicate the fact that the oil has *not* been filtered, suggesting a different taste. Fresh unfiltered olive oil usually has a slightly cloudy appearance and is therefore sometimes called *cloudy olive oil*. This form of olive oil used to be popular only among small scale producers, but is now becoming "trendy", in line with consumer's demand for products that are perceived to be less processed (Peri, 2014). Many oils are marketed as first cold pressed or cold extraction. "Cold" means no heat is added during extraction. "Pressed" means that the olives are crushed in a mill to extract the oil. In the European Union (EU), these designations are regulated by Article 5 of Commission Regulation (EC) No 1019/2002 on marketing standards for olive oil. This article states that to use these designations the olive oil producers must prove that the temperature of malaxation and extraction was under 27 °C. The temperature is crucial due to its effect on olive oil quality. When high temperatures are applied, more volatile aromas are lost and the rate of oil oxidation is increased, producing therefore lower quality oils. In addition, the chemical content of the polyphenols, antioxidants and vitamins present in the oil is reduced by higher temperatures. The temperature is adjusted basically by controlling the temperature of the water added during these two steps. High temperatures are used to increase the yield of olive oil obtained from the paste (NAOOA, n.d.).

The olive oil and its derivatives can follow three main channels:

- They can be destined to industries like canning, packaging industries or refineries, to be used as raw materials for further processes.
- They can be destined to the export.
- They can be transferred to wholesalers, agents, or other intermediaries to be placed on the market.

The entrance in foreign market can occur through export or in the internal market with *retail,* specialized selling, or in the *Ho.Re.Ca* (*Hotellerie-Restaurant-Cafè)* with the selling in these sectors. (ISMEA, 2021). Figure 1-2 summarizes the entire process of producing and distributing olive oil.

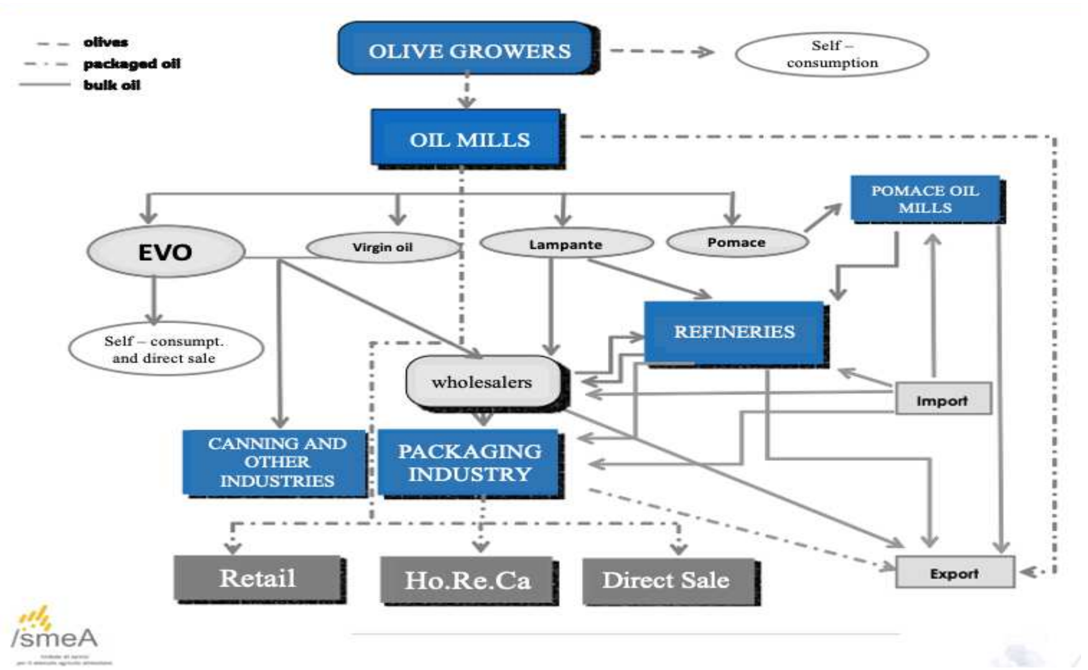

Figure 1-2: Olive oil's supply chain (ISMEA, 2021)

Another way of placing these products in the market is the short supply chain. This typology of supply chain is characterized by a limited number of intermediaries to allow less steps between producers and consumers. The distribution of the product can be applied through direct sale, even online, in the local markets, with wholesales or through small local traders. In addition, the farmers can directly sell their oil to consumers in the farm (ISMEA, 2021).

1.3 **The European policy framework**

Talking about the European framework for the olive oil, one of the main Regulations being considered is the ***Regulation 2022/2104*** supplements the EU ***Regulation 1308/2013*** (Single CMO) with regard to marketing standards of olive oils. Both apply to oils sold to the final consumer, presented as such or in a food product. Regulation (EU) no. 1308/2013 already defines and distinguishes olive and olive-pomace oils (Art.2), aspect already explained in *Chapter 1*: Virgin olive oils, refined olive oil and olive oil. It also classifies the olive-pomace oils in crude olive pomace oil, refined olive pomace oil and olive pomace oil. In Annex I of

Reg. EU 2022/2104, it establishes for each category of oil the requirements of: purity, considering parameter like fatty acid profiles, and sterols content; quality with acidity, peroxide index, absorption in the UV; organoleptic characteristics with defect median, fruitiness median and fatty acid ethyl esters. After this the Reg. defines many aspects, specifying the conditions for the mixtures with other vegetable oils and food ingredients, their conditioning, the mandatory and voluntary label information and the special storage conditions, arriving at the aspect of the origin. Talking about the place of origin of oils, as an exception to the general notion of country of origin of food provided for in Reg. EU 1169/11 (art. 2.2.), this corresponds to the area where the olives were harvested and pressed. The indication of origin on the label is mandatory for virgin oils and prohibited for olive oils composed of refined olive oils and virgin olive oils, as well as olive-pomace oils (Art. 8). If the olives were harvested in a country other than the country where the mill is located, the label must instead show "*(extra) virgin olive oil obtained in (EU or member state) from olives harvested in (EU or member state)*." Several hypotheses are configured**:** in the case of olive oils originating in a Member State or a third country, the Member State, the Union or the third country, as the case may be, is indicated. In the case of mixtures of olive oils originating in more than one country, sentences may be reported as appropriate, like the following: "*blend of olive oils originating in the European Union*," meaning a reference to EU origin. Regional references are reserved exclusively for products registered as PDO or PGI, according to Reg. 1151/2012. Names of trademarks or enterprises whose applications for registration were filed by Dec. 31, 98 are not considered '*place of origin* '(and are therefore exempt from the prohibitions on regional references). Products imported from third countries report to the country of origin, meaning the place of last substantial processing, according to Reg. EU 952/2013 (Articles 59-63) and not to the '*place of origin* 'referred to in this regulation. The alphanumeric code identifying the packaging plant (Reg. 2022/2105, Art. 6) must be given on the label- '*where applicable*' of extra virgin and virgin olive oils, olive oils composed of refined and virgin oils, olive-pomace oils. Conversely, it is optional, even for such oils (and indeed not even considered, in the regulation under consideration) to indicate the location of the establishment on the label (reg. EU 2022/2104, Art. 9). After this it continues to specify other aspects such as the optional label information, with the confidential mentions ("first cold pressing"), the organoleptic characteristics, maximum acidity and the collection campaign. At the end it defines the necessity of the recall of olive oil in vegetable oil blends and in other food if present (Dongo, Pietrollini, 2022).

The EU ***Reg. 1151/2012*** abrogates and replaces Regulations n° 509/2006 and 510/2006 which regulated the protection of PDOs (protected designations of origin), PGIs (protected geographical indications) and TSGs (traditional specialities guaranteed). These certifications are significant indicators of oil quality. An oil with these quality marks has passed rigorous analytical and physical tests, ensuring a high-quality product. These are the result of a rigorous evaluation process that considers various aspects, from the origin of the olives to the methods of production and processing. The PDO certification requires that the entire production process takes place within a well-defined geographical area, thus ensuring a close link with the territory of origin. The PGI certification, on the other hand, is slightly less restrictive, requiring that at least one stage of the production process is carried out in the area specified by the regulations. The Certification process is voluntary and is undertaken by the producer to ensure the quality of their oil. A third and recognized body is responsible for certifying the product's compliance with specific quality standards and a predefined production regulation, thus offering an additional guarantee to the consumer. PDO and PGI certifications protect the consumer and benefit the producer. They ensure that the extra virgin olive oil has been produced following traditional methods and respecting high-quality standards, offering a traceable and authentic product. These quality marks benefit the producer because they allow the promotion of products having certain characteristics, encouraging the diversification of agricultural production. They protect the intellectual property of farmers and producers improving income opportunities of farmers, particularly in less favored or remote rural area (Oro del Salento, n.d.). This Reg. represented an important point regarding these aspects, but actually it is no longer in force after the 12 /5/2024. It was repealed by the ***Reg. 2024/1143***. The aim of the regulation is to establish a standardized and conclusive system of geographical indications that protects the names of wines, spirits and agricultural products that have properties, characteristics or a reputation associated with the respective place of production. This is intended to strengthen producers' ability to operate and compete, along with legal certainty and the concept of sustainability. There are many innovations introduced with this, but the main one in terms of traceability, is the more visibility on the label for the name of the producer, that has to be shown in the same field of vision as the geographical indication. Then sustainability as an optional obligation for all producers, paying more and more attention on this topic and online protection of geographical indications. As last topic it highlights the use of the geographical indications to designate the ingredient of a processed product (Wolf Theiss, 2024).

Another important regulation regarding the olive oil, and in this case the topic of traceability, is the **Reg. 178/2002**, which was the first framework legislation relating to food and the first one to introduce this topic. The reason is that the olive oil represents one of the agri-food products most exposed to frauds. The aspect of traceability is explained in Art.18 of Chapter II. It is defined as the ability to trace and follow a food or feed at all stages of production. This tool helps to understand the identity, history and source of a product, but it does not make a food safe, because it is a management tool. In fact, it allows the assurance of food safety and actions to be taken if food is found not to be safe. Practically, introducing this aspect, at each stage in the food chain, stakeholders must be able to identify what is received (raw materials from the previous stage in the chain), identify where the product is sent (to the next stage in the chain) and make information available on demand. An important aspect is that each stage in the food chain is responsible for the operations under their control with no requirement for whole chain traceability. Chapter IV sets out rules regarding the establishment of a *rapid alert system*, a tool for the notification of any direct or indirect risk to human health from food or feed inside the European Union, together with the establishment of emergency measures for food and feed of Community origin or imported from a third country. This part of the Reg. also specifies the development of a general plan for crisis management in the field of safety and the establishment of a crisis unit and its tasks (FAO, 2024).

Another very important Regulation in which the aspect of traceability is included is the ***Reg. 1169/2011*** on the provision of food information to consumers. This one provides the basis for the assurance of a high level of consumer protection in relation to food information, taking into account the differences in the perception of consumers and their information needs. It lays down general principles governing the right of consumers to information, with particular regard to food labelling. The provisions apply to business operators at all stages of the food chain, where their activities concern the provision of food information to consumers. It assists in the free movement of foodstuffs inside in the EU internal market stating that the food information should not be misleading and should be provide in a clear, accurate and easy way to understand format, so the consumer can make “informed” choices. It is applied to all foods intended for the final consumer, including foods delivered by mass caterers, and foods intended for supply to mass caterers. The Reg. sets down the mandatory information that must be specified on food products, the general principles of fair information practices and rules for voluntary food information provision. In the Chapter IV are highlighted the information that must appear on food labels (mandatory): the name of the food; weight or volume (net quantity); ingredient list; allergen information; genetically modified ingredients (if present); date mark and storage conditions; prepare instructions; name and address of manufacturer, packer or seller; place of origin; lot (or batch) mark; nutrition information (since 2016). Additional information may also be provided, such as the cooking instructions or serving suggestions. In details for the traceability aspect, as already said the name and address of manufacturer is mandatory: this because the consumers can contact, if it is necessary, the manufacturer, if they have a complaint about a product of if they wish to know more about it. Then as another mandatory information, the place of origin. The label must show clearly where the food has come from if it would be misleading not to show it, for example, a tub of 'Greek Yogurt' which was made in France. The origin of the main ingredients will have to be given if different from where the final product is made. Under the current rules, country of origin labeling is mandatory for fresh beef, fruits and vegetables, honey, olive oil or where the absence of such labeling may mislead the consumer. Regulation 1169/2011 extends the mandatory country of origin labeling to meat listed when the country of origin of a food is not the same as its primary ingredient (FAO, 2023).

1.4 **The Italian policy framework**

After discussing the European regulatory framework for the olive oil, now the National level is considered for Italy. On the 27/12/2023 the Italian Parliament enacted the Law n. 206 regarding the dispositions for the valorization, promotion and protection of the made in Italy, here and abroad. As general principles, laid down in Art.1, this Act contains organic provisions designed to enhance and promote the productions of excellence, the cultural heritage and national cultural roots, as factors to be preserved and passed on not only for purposes of identity, but also for the growth of the national economy. In the Art. 2 is highlighted that State, regional and local governments act in accordance with the principles of recovery and promotion of traditions, the development of crafts and the support of young people working or intending to work, and to study, in the fields which determine the success of Made in Italy in the world. In the part 2 of this article the act states that the measures of promotion must be in line with the principles of environmental sustainability and with the transition of the production processes through digitalization and Eco innovation, this for making more efficient the processes without compromising the peculiar characteristics of a product or activity (Parliament, 2023). The rule, actually, does not only concern the agri-food sector, but is more wide-ranging and potentially involves all sectors of industry; however, the link with the food sector is evident, both because of the special importance of traceability in this sector, and because a reading of the parliamentary work reveals a number of proposed amendments - such as the unapproved Article 47-bis, entitled 'Measures for the promotion of modern digital systems in the food sector' - that reveal a clear link between this rule and the agri-food industry. (UNIPR, 2023). In the act several articles are related to different supply chains of the agri-food sector, from where the most important products made in Italy belong, but in details the art. 9 is related to the valorization of the supply chain of the virgin olive oil. For doing this, granting an higher quality for the virgin olive oil, the European Commission has set out its registration, within the national agricultural information system, of the deliveries of the olives. The registrations have to be done within 6 hours after the delivery of the olives to the traders by the olive growers. Regarding the transition of the production processes through digitalization and Eco innovation the art. 47 is called: *The blockchain system for the traceability of the supply chain*. (Parliament, 2023). It focuses on the possibility of using technologies based on distributed ledgers (or DLT, an acronym derived from the English expression distributed ledger technologies and indicating the family of technologies to which the blockchain belongs) to ensure the traceability of the supply chain. (UNIPR, 2023) In the part 2 of this article the act claims that is set up at the Ministry of Enterprise and of the Made in Italy, a national catalogue for the census of solutions technologies. The national catalogue provides infrastructure nodes meeting the requirements of the European Blockchain Services Infrastructure, in order to promote the establishment of a technology-based network, facilitating interoperability between technologies developed within the Italian Blockchain Services infrastructure. The definition of the technical standards that these technologies must possess for the purposes of inclusion in the catalogue, as well as the methods of maintenance and operation of the same, will be the subject of a future decree of the Minister of enterprises and made in Italy. The national catalogue will also provide for the census of nodes that meet the requirements laid down by the “European Blockchain Services Infrastructure”. This is a partnership set up in 2018 comprising 29 countries with the aim of exploiting blockchain to create cross-border services for public administrations and businesses, in order to connect this European project with national initiatives and, in particular, with the “Italian Blockchain Service Infrastructure”. It is a project in turn promoted by many other partners, which aims to test the design and development of an ecosystem based on distributed ledger technologies. Article 47 therefore does not have a truly binding scope, but is rather a programmatic rule, aimed at innovating the country's production systems and dealing, on a voluntary basis, with the age-old problem of the opacity of the supply chains, which is ill-suited to the excellence and quality of the Italian agri-food tradition. The experimentation of blockchain therefore represents, together with the introduction of the “made in Italy” mark referred to in Article 41 of the law in question, a tool aimed at strengthening the reliability of Italian products and consequently their attractiveness, offering the market and consumers concrete proof that the entire supply chain of an Italian product has taken place in Italy (UNIPR, 2023).

1.5 The Blockchain

The development of blockchain technology happened unrelated to agri-food supply chains. In 2008, the creation of Bitcoin, the world's first digital cryptocurrency, by Satoshi Nakamoto, spurred the rise of blockchain. The innovative idea of a decentralized ledger was highly commended for its potential to provide transparency and accountability while protecting the privacy of stakeholders within a blockchain network. Independent stakeholders of the network share the same set of data without directly interacting with each other, creating a system where users are not dependant on trusting one another, in other words, a 'trust less' system, that operates based on a consensus mechanism. A blockchain-enabled system differs from the traditional data governance structure of a centralized database where a party or 'node' within the network is trusted by all other nodes and responsible for checking and distributing duplicate data to each actor. In many agri-food supply chains it is difficult to pinpoint a single trusted party that can verify information on behalf of all stakeholders; hence, the need for a decentralised traceability system. To eliminate the need for a central and trusted node, blockchain prevents data manipulation by continuously encrypting data into 'blocks', which are then added to a chain of existing blocks in an irreversible linear sequence. The encryption process of data involves hashing, which is a cryptography method that converts any form of data input into a unique string of text that can be stored on-chain. The process is one-way, meaning that participants may not decrypt and obtain the transactional information of other participants if they are not provided access to it. Since each new block is created using the hash of the previous block, whenever any on-chain data is changed, all subsequent blocks will reflect the change. As a result, blockchain fulfils the desired characteristics of a decentralised ledger that is consensus driven, yet secure and tamper evident. (Anon., n.d.)
The blockchain consists of five defining features (UNDP, 2021):

I. *Distributed ledger*. Blockchain is an open distributed ledger that can record transactions between two parties, efficiently, in a verifiable and permanent way, by bundling them together in cryptographically linked blocks. The sequence of blocks differentiates a blockchain from conventional distributed ledgers, which act as a form of a database.

II. *Peer-to-peer (P2P) network*. Peer discovery and data sharing does not require a trusted and central middleperson. The distributed nature of the ledger makes it resilient as information remains accessible even if many peers are offline.

III. *Computational logic*. The use of cryptographic techniques enhances security and ensures that systematic protocols are in place. It strengthens confidence in the automation of work processes to enhance efficiency.

IV. *Transparency and privacy*. Users can choose to remain anonymous or provide proof of their identity to others. During a transaction, encrypted information between blockchain addresses is exchanged, allowing the protection of users' identity.

V. *Immutability*. Once a record has been added to the ledger as a block, it cannot be secretly altered since all subsequent records will be linked to it. Any changes to past records must be validated via consensus amongst all network participants (UNDP, 2021).

These features are highly valuable in agri-food supply chains. The blockchain acts as a single source of truth with full data visibility possible for all stakeholders. It can complement existing centralised systems through a distributed system providing permanent and transparent records trusted by all actors.

Several types of blockchains exist, each with contrasting functionalities and permissions to meet the needs of diverse stakeholder relationships within the network (UNDP, 2021):

- *Public blockchain*: governed by democratic principles with no access restrictions. Anyone with access to the blockchain can send or validate transactions. These networks typically offer economic incentives for validators who operate through consensus mechanisms.
- *Private blockchain*: permissioned. One cannot join it unless invited by the network administrators and participant, and validator access is restricted. Under a permissioned blockchain, members of the network are usually known to each other, and consensus mechanisms are simpler. While private blockchain provides more privacy, scalability, and ease of governance, it may be less tamper resistant.
- *Consortium blockchains*: semi-decentralised. It is also permissioned, but instead of a single organisation controlling it, multiple actors might each operate a node on such a network. The administrators of a consortium chain restrict users' reading rights as they see fit and only allow a limited set of trusted nodes to execute a consensus protocol (UNDP, 2021).

Businesses tend to opt for private or consortium blockchains to manage the read and/or write permissions of specified parties on the network. Agri-food supply chains actors may also prefer permissioned blockchains to benefit from greater security and efficiency. Additionally, a hybrid blockchain may be built by combining features of both private and public one. Organisations can control and customise the blockchain architecture to meet their needs. In a hybrid blockchain, the private system may protect users and disclose selected information to the public. The public anonymity of users can be maintained as identities are only released to another user during the transaction process. For example, customers may be able to publicly view the source of their products but may not be able to access restricted information such as a company's sales values (UNDP, 2021) (Figure 1-3).

FEATURES	PUBLIC no centralised management	CONSORTIUM / PRIVATE multiple organisations / single organisations
Identity of Participants	Permissionless Anonymous Could be malicious	Permissioned read and/or write Identified Trusted
Speed of Processing Transactions	Can be set to open read and/or write Slow E.g., Bitcoin: Block Approval Frequency of 10 min. or more	Fast
Unique Value Proposition	Disruptive Disintermediation, removing the need for middlepersons and the corresponding cost for a large public system involving many trustless stakeholders Transparent to the public	Functional Can substantially reduce transaction costs Lower data redundancy Higher transaction frequency More transparency within the network

Figure 1-3: Comparison between different types of blockchains (UNDP, 2021)

A consensus mechanism is a predetermined set of rules that all parties follow to maintain the network. Consensus mechanisms govern the information added to a ledger. New blocks of data entries and transaction information are validated through a consensus algorithm before it is added to the existing blockchain. The consensus mechanism bypasses the need for a central authority through a pre-existent agreement among different nodes to maintain a consistent record of information. Different types of blockchains may adopt different consensus mechanisms. Smart contracts replace traditional contracts by having terms of agreements directly written into lines of code, enabling a self-executing mechanism that can exist on a blockchain network. Stakeholders can predefine the rules of a business relationship and codify the transaction protocol on a blockchain platform. Transactions can then be automatically executed once conditions are met, removing the need for intermediaries. Consequently, simple yet manual processes such as verification of information can be replaced, allowing transactions to proceed with greater efficiency. Blockchain technology supports the use of smart contracts since the data stored is immutable and secure, allowing transactions to be conducted securely. With smart contracts, farmers can benefit through regularly scheduled payments to support their livelihood. Additionally, information collected is securely and transparently shared among stakeholders who become aware of fair payments made to these farmers. Problems of inequity and human rights violations can be better managed through direct engagements with farmers through smart contracts (Anon., n.d.).

Along with blockchain's advantages there are some significant challenges. Blockchain networks can be slow and inefficient due to the high computational requirements needed to validate transactions. As the number of users, transactions, and applications increases, the ability of blockchain networks to process and validate them in a timely way becomes strained. This makes blockchain networks difficult to use in applications that require fast transaction processing speeds. Various solutions have been proposed to try to overcome scalability issues, including scaling systems for creating off-chain channels that allow for faster and more cost-effective transactions. Another challenge is related to the energy consumption. The process of validating transactions on a blockchain network requires a lot of computing power, which in turn requires a lot of energy. This has led to concerns about carbon emissions and the environmental impact of blockchain technology. Some blockchain projects have adopted alternative consensus mechanisms, such as PoS, which consume significantly less energy. Even if one of the strengths of the blockchain rests within its security, this is not at 100%. There have been cases of security breaches and hacking attacks on blockchain networks, and these problems can result in monetary losses and damage to the integrity of the network. To mitigate risks, companies are working to improve the security of blockchain networks and applications, including formal verification of smart contracts to help identify potential vulnerabilities and using multi-signature wallets for storing and managing digital assets. Another challenge is related to its complexity. This technology requires a high level of technical expertise to implement and maintain. Tech challenges may slow down the widespread adoption of blockchain technology and discourage potential users and developers from engaging with it. Blockchain's complexity can also lead to errors and inefficiencies in implementation. Solutions to solve this challenge are the development of user-friendly interfaces, streamlined onboarding processes, and educational resources that simplify the complexities of blockchain. Interoperability is another crucial challenge facing the system.

There are currently many different blockchain platforms, each with its own protocols and standards, and they often do not work well together. This lack of interoperability can lead to inefficiencies, as individuals and companies may need to navigate multiple platforms and use a number of tokens or cryptocurrencies to interact with different networks. This fragmentation can also hinder collaboration and innovation and prevent the seamless exchange of data and value between different blockchain ecosystems. By promoting collaboration between various blockchain platforms, the industry can work towards creating a cohesive, efficient, and inclusive digital landscape that benefits users, developers, and businesses (Forbes, 2023).

CHAPTER 2
THE OLIVE OIL MARKET

2.1 European scenario

2.1.1 Areas dedicated to cultivation

The olive trees are especially cultivated in nine EU Member States: Greece, Spain, France, Croatia, Italy, Cyprus, Malta, Portugal and Slovenia. Overall, in these countries, in the 2017 the olive groves covered an area of 4.5 million hectares (more than the half in Spain), largely cultivated for the production of the olive oil: only in Greece the production of the table olives represents the 10% of the olive groves (European Parliament, 2017). The main producing countries, considering the number of hectares, were Spain with the 55% of the total and 2.5 million Ha, followed by Italy with 23% and around 1 million Ha, Greece with 15% and 670,000 Ha, and Portugal with 7% of the total and 300,000 Ha. The other States represent less than 1% of the total with 40,000 Ha (Eurostat, 2019) (Figure 2-1).

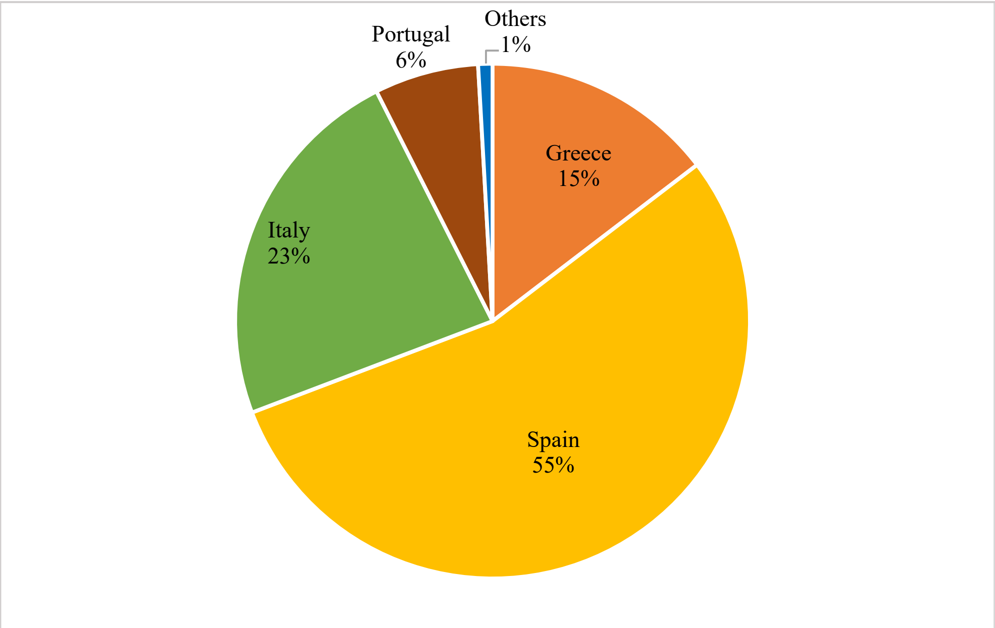

Figure 2-1: % of hectares of olive trees (Eurostat, 2019)

Consulting the data available at Eurostat for the years 2012 and 2017, the number of hectares for the main producers of olive oil remained almost the same, being in 2012 around 4.6 million Ha and 4.5 million in 2017, booking at maximum a reduction of 5% for Greece and 4% reduction of hectares for Italy and Portugal (Eurostat, 2019) (Figure 2-2).

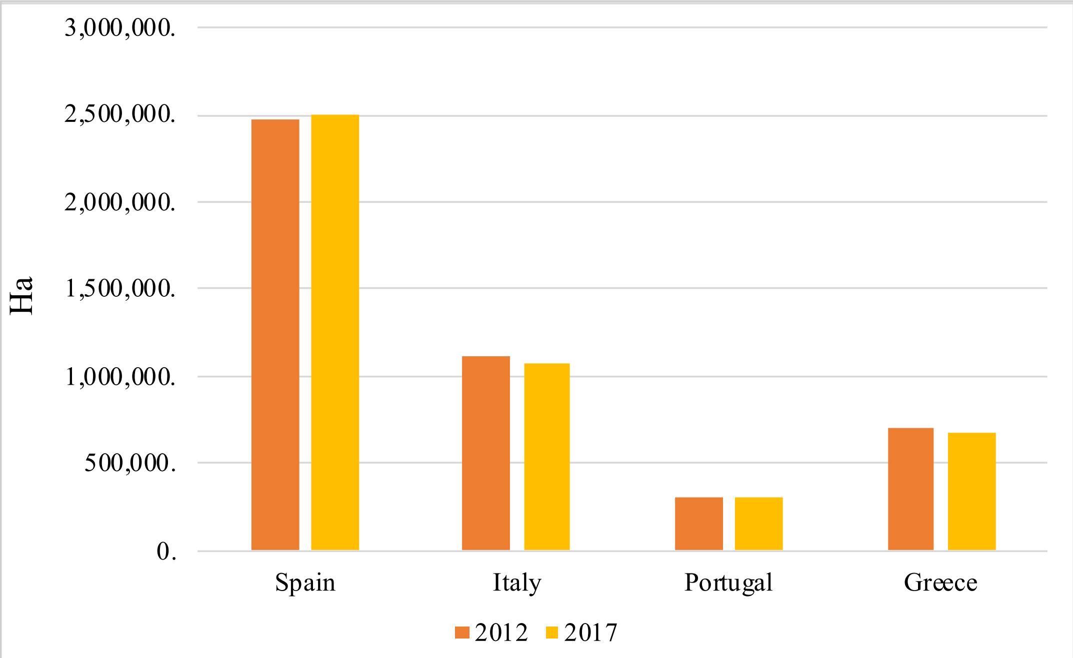

Figure 2-2: Number of hectares of olive trees (2012 vs 2017) (Eurostat, 2019)

Considering the average area with olive trees, in 2013 Spain had the highest number, with 5,8 Ha for each farm, followed by Portugal with 2,8 Ha/farm. The other countries had an average area less than 2 Ha for farm. Actually, these values represent an average that come from a result of very different situations. From a more detailed analysis it results that in Spain and Portugal more than 40% of the farms has more than 20 Ha of olive groves. In the other producing States, more than 90% of the farms have an area of less than 5 Ha of olives trees.

In the farms specialized in the cultivation of the olives, most of the land is occupied by olive trees, accounting for the 83% of the total. The remaining land is mainly destined for the set-aside (6%) and other crops, always 6%. The cultivation of cereals and permanent crops other than olives (like fruits or vineyards) account respectively for the 3% and 2% of the total land. These values come from 2013 but they give an idea of the degree of specialization of farms working in the olive oil sector (European Parliament, 2017) (Figure 2-3).

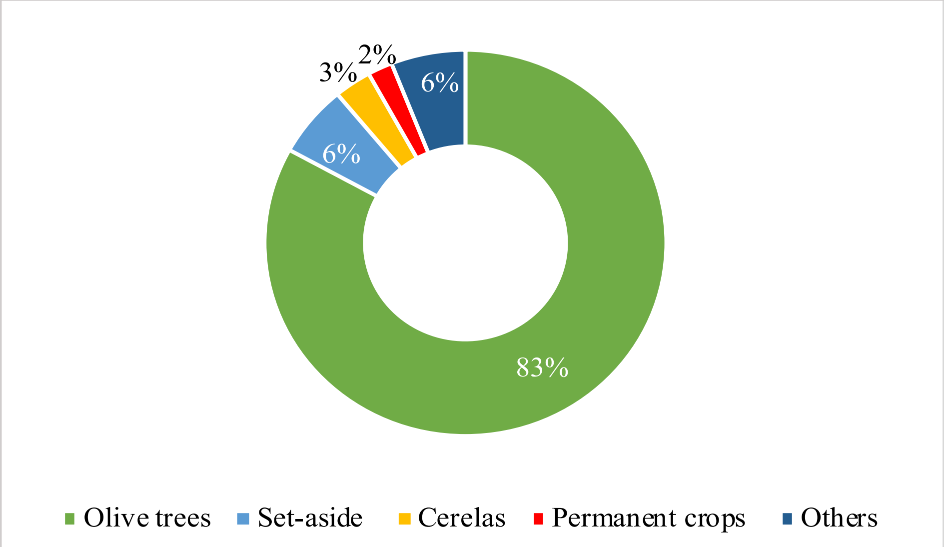

Figure 2-3: Use of land in olive specialized farms in Europe (2013) (EP, 2017)

2.1.2 Olive oil productions

The UE is the major producer, consumer and exporter of the olive oil in the world. It produces alone around 67% of the world olive oil. Considering the period 2013-2023 the production in tons of olive oil was quite fluctuating, with the highest level in the year 2013/2014 around 2.5 million tons produced and the lowest value in 2014/2015 with 1.4 million tons produced. For the other years there was a variable trend but for all the period considered the average value is 2 million tons produced (EC, 2024) (Figure 2-4).

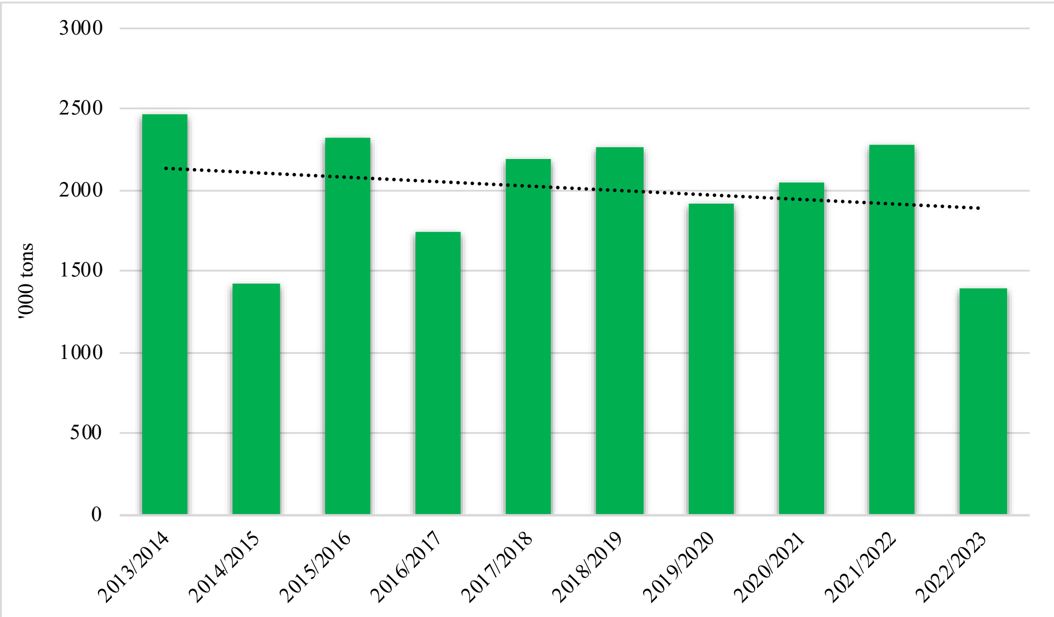

Figure 2-4: Olive oil production (1,000 tons) (EC, 2024)

Considering the productions for the main producing countries, in 2023 the highest value was related to Spain with 853,000 tones (57% of the total), then Italy with 328,500 tones (22% of the total), Greece and Portugal both representing 10% of the total produced and respectively 155,000 and 157,600 tones. The remaining countries represented less than 1% of the total (EC, 2024) (Figure 2-5).

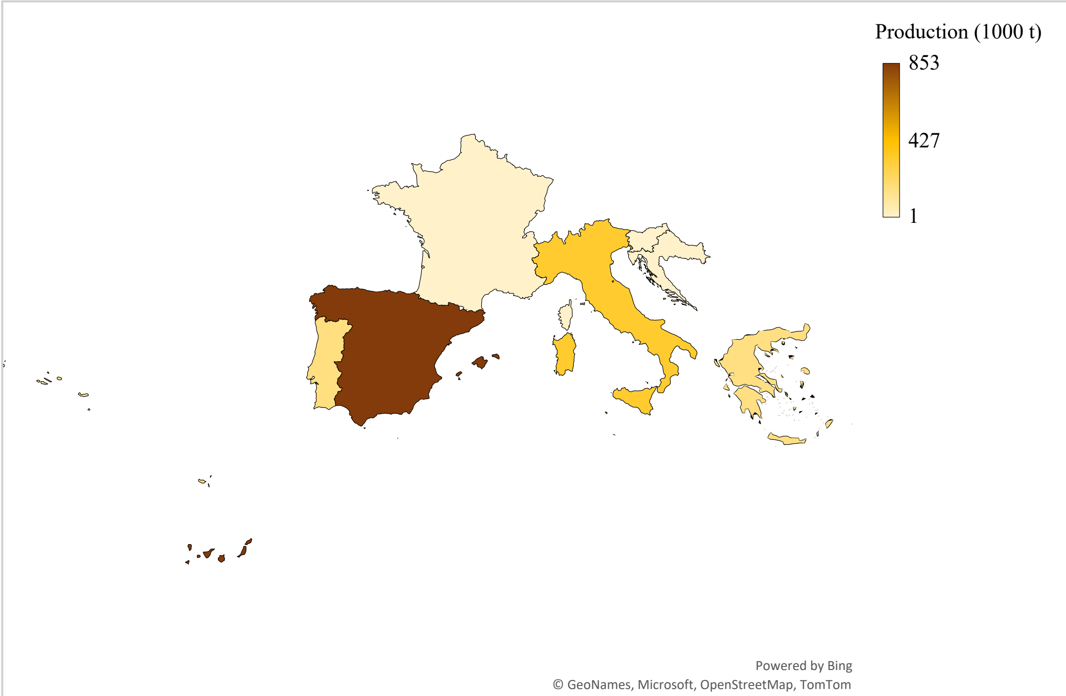

Figure 2-5: Olive oil production in Europe (EC, 2024)

Comparing the production of olives, in tons, for the 2022 and 2023, the last year with data available shows a significant increase from the previous one. A +59% of tons of olives produced for France (3,500 – 5,558 tones), a +36% for Italy (240,900 – 328,500) then Spain with +28% (665,800 – 853,000), Portugal with +25% (125,900 – 157,600). On the other hand, the other countries registered a decrease in the production with the highest value related to Greece, -55% from the previous year (345,500 – 155,000), Slovenia -29% (700 – 500 tons), and Croatia with a -31% (5,100 – 3,500 tons) (EC, 2024).

2.1.3 Export and import

EU Member States exported over 1.6 million tons of olive oil in 2018, worth €5.7 billion. Almost two thirds of these exports went to other EU Member States (63%, or 1.0 million tons). This represents a 15% increase in the value of EU Member States' total exports compared with 2013. Among EU Member States, Spain exported 301,400 tons of olive oil to non-EU Member

States in 2018 (53% of extra-EU exports of olive oil in weight). This makes Spain by far the largest EU exporter of olive oil to the rest of the world, followed by Italy (191,000 tons, 33%), Portugal (56,000 tons, 10%) and Greece (20,600 tons, 4%). These four countries accounted for 99% of all extra-EU exports of olive oil in 2018 (Figure 2-6).

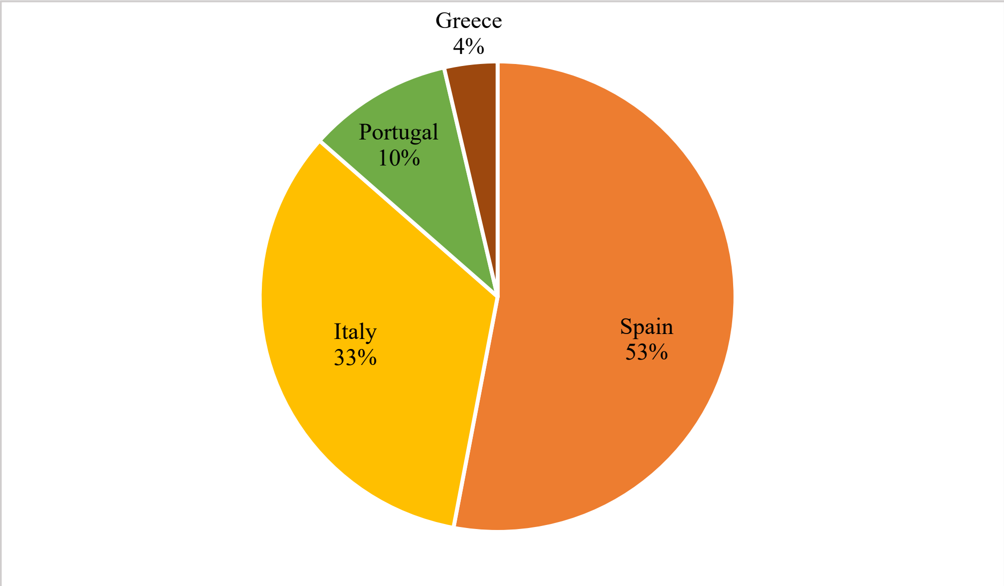

Figure 2-6: Olive oil exported from Europe (Eurostat, 2019)

Over a third of EU olive oil exports went to the United States (203,000 tons, or 35% of extra-EU exports of oil olive), followed by Brazil (65,000 tons, 11%), Japan (52,000 tons, 9%), China (35,000 tons, 6%), Canada (31,000 tons, 5%) and Australia (29,000 tons, 5%).

In 2018, the EU Member States imported 1.2 million tons of olive oil, worth €3.9 billion. Majority of these imports came from other EU Member States (85%, or 1.0 million tons). The value of olive oil imports to the EU Member States increased 10% compared with 2013. The main non-EU country from which the Europe imports the olive oil is Tunisia: for the period 2018-2023 the EU always imported the same quantity of oil, up to 56,700 tons, corresponding to the 9% of the 2022/2023's production (Eurostat, 2019).

Table 1 shows the variations as % in volume and % of value of the olive oil imported for the main importer States, comparing the first trimester of the 2023 with the first trimester of 2022. The highest increase was registered for Turkey, with a +283% in the import of olive oil as volume, linked to a +243% as increase in terms of value. The highest reduction in term of % of volume was related to Belgium, with a -64.5%, accompanied by a -5% in value. For some States, like Italy, even if there was a reduction in the terms of volume, this didn't always correspond to a reduction in terms of value. In fact, it registered a -20% in the import of olive oil as volume, but a +17.8% as value of olive oil imported. The same was for France (-5.8%

volume vs 31.1% value), Netherlands (-6.2% volume vs 19% value), Switzerland (-8.8% volume vs 11% value) and Sweden (-1.4% volume vs 21% value) (ISMEA, 2023).

1° Trim. 23/ 1° trim. 22	Import	
States	Var. % volume	Var. % value
Italy	-19.9%	17.8%
USA	10.4%	44.3%
Spain	12.9%	57.6%
Portugal	6.3%	55.9%
France	-5.8%	31.1%
Brazil	16.3%	54.9%
UK	-24.5%	-17.7%
Turkey	283.0%	243.0%
Canada	-19.2%	-0.2%
Japan	-23.0%	-5.9%
Netherlands	-6.2%	19.0%
South Corea	-23.3%	-7.1%
Switzerland	-8.8%	11.1%
Belgium	-64.5%	-5.0%
Sweden	-1.4%	21.0%
Thailand	2.9%	38.9%
Norway	12.9%	
Irland	11.5%	47.3%

Table 1: Variations as % in volume and value of the olive oil imported (ISMEA, 2023)

Talking about export, always considering the variations between the first trimester of 2023 and the first one of the 2022, also in this case the highest variation was related to Turkey, with a +188.5% in terms of volume and even 300% as value (Table 2). This followed by Greece with a +138.8% as volume and 217.5% as value. For Italy also in this case there was a reduction considering the export of olive oil in terms of volume, but it was accompanied by a slight increase as % of value, with a +9.7%. The same was for Portugal (-23.7% volume vs 5.1% value) and Netherlands (-18.9% volume vs 15% value) (ISMEA, 2023).

1° Trim. 23/ 1° trim. 22	Export	
States	Var. % volume	Var. % value
Italy	-19.4%	9.7%
USA	11.0%	18.6%
Spain	-33.5%	-3.3%
Portugal	-23.7%	5.1%
France	56.4%	62.4%
Turkey	188.5%	300.5%
Netherlands	-18.9%	15.0%
Greece	138.8%	217.5%
Argentina	20.7%	35.8%
Belgium	-11.4%	0.3%
Chile	-42.5%	-24.4%
Australia	81.7%	90.2%

Table 2: Variations as % in volume and value of the olive oil exported (ISMEA, 2023)

Talking about prices of the olive oil for the main producing countries, the values are taken as average of the year 2024 (until July) for the evo oil. As the graph shows the highest price for the evo oil is related to Croatia, where the average in 2024 is 12.6 €/kg. Then comes Italy with 9.2 €/kg as average price. For the other countries the price is always around 8 €/kg, except for the Portugal where the price is closer to 9 €/kg (EC, 2024) (Figure 2-7).

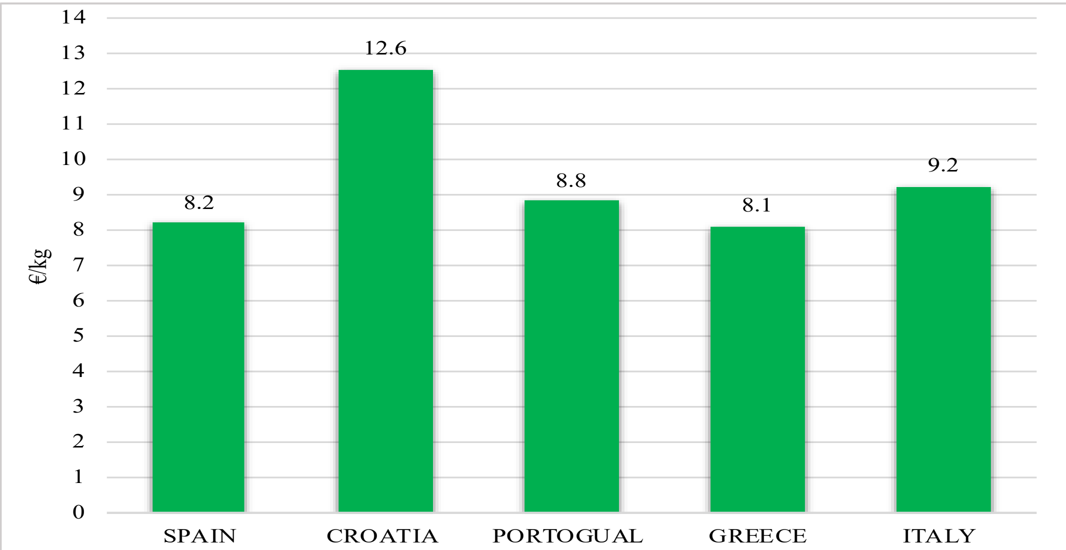

Figure 2-7: Prices of EVO oil (average 2024) (EC, 2024)

As it is well known, the prices for a product, like the olive oil, are subjected to a high variability, even between months so even more between years. In fact, the evolution of the price since last year for the Spain is registered at +28%, for Italy +33% and for Greece +35%, with the highest percentage.

For the virgin olive oil, always considering these three main producing countries, the prices in June 2024 were 7.4 €/kg in Spain, 7.8 €/kg in Italy and 6.7 €/kg in Greece. For this product the evolutions since the previous year are quite similar, with +24% for Spain, +30% Italy and +39% in Greece, where there's the highest variation also for this type of oil. The next figure 2-8 shows the comparison between the prices for the evo and the virgin oil in June 2024 (EC, 2024).

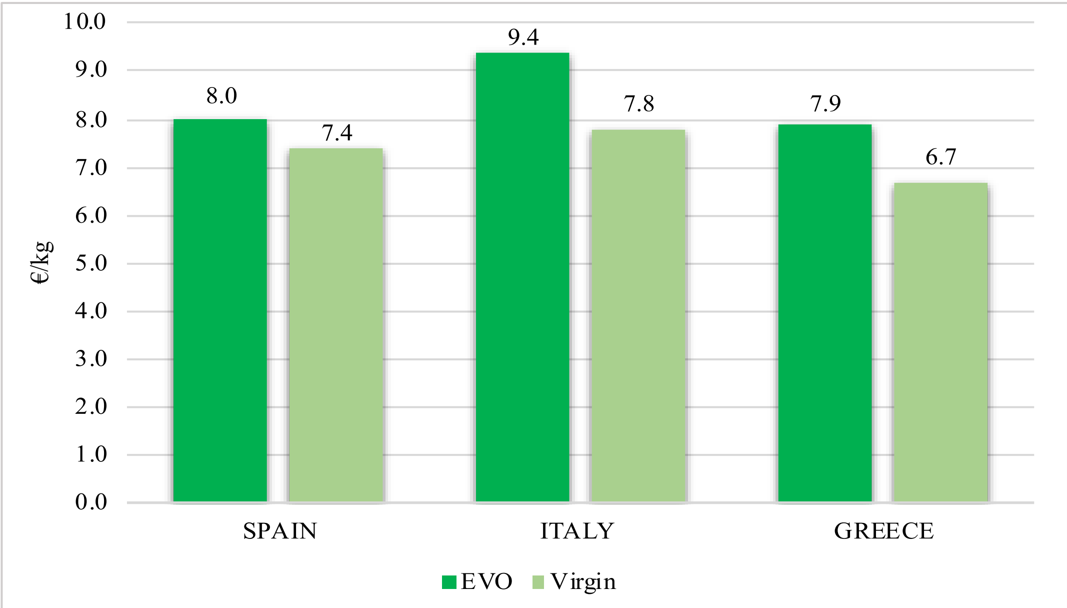

Figure 2-8: Comparison of prices for EVO and virgin oil (June 2024) (EC, 2024)

2.2 **Italian Scenario**

2.2.1 Areas dedicated to cultivation

The Italy plays a very important role in the world. In fact, it represents the 1° consumer of olive oil, the 2° producer (after Spain), the 1° importer and the 2° exporter (also in this case after Spain). It is clear that the production of this product is focus on the Mediterranean basin, and especially in Spain and Italy, countries that represent almost the total of the global export (Spain the 60% and Italy 20%). The Italian production covers around the 15% of the world total, while Spain around 45% (ISMEA, 2023). In Italy in 2023 there was more than 1 million hectares of area with olive trees (2 Ha as average for farm) and almost 4,500 active olive oil mills. Considering the number of hectares with olive trees in the period 2020-2023, as we can see from the Figure 2-9, the overall trend is negative, showing a decrease in this value, up to -5% in the number of hectares. The lowest value was in the last year, with 1,078 million hectares of olive trees (ISTAT, 2024).

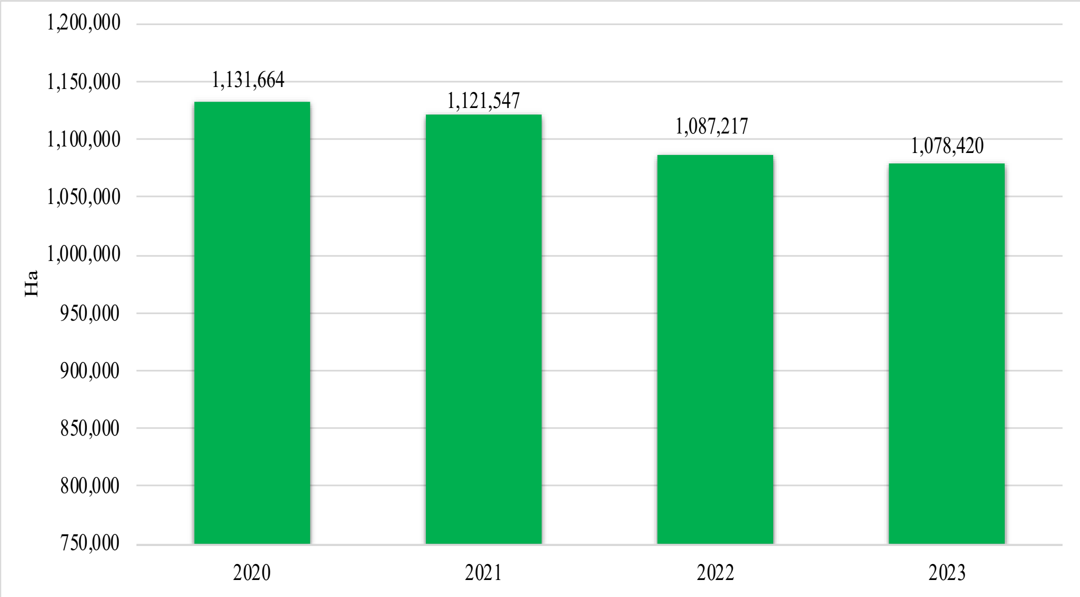

Figure 2-9: Trend of hectares of olive trees in Italy (2020-2023) (ISTAT, 2024)

Considering the regional scenario in 2023, the highest number of hectares was related to Puglia, with 32% of the total (343,930), followed by Calabria 17% (181,967) and Sicily with 14% of the total (145,620) occupying the first three positions. The other regions represented less than 10% of the total number of hectares of olive trees (ISTAT, 2024) (Figure 2-10).

Figure 2-10: Hectares of olive trees (2023) (ISTAT, 2024)

Considering the number of farms working in the olive oil sector in 2020 these were 619,000. In this case the first place was occupied by Puglia with 26% of the olive oil companies (161,009), followed by Sicily with 16% (96,176) and Calabria with 13% of the total (79,965).

Also in this case the other regions represent less than 10% of the total (ISMEA, 2023) (Figure 2-11).

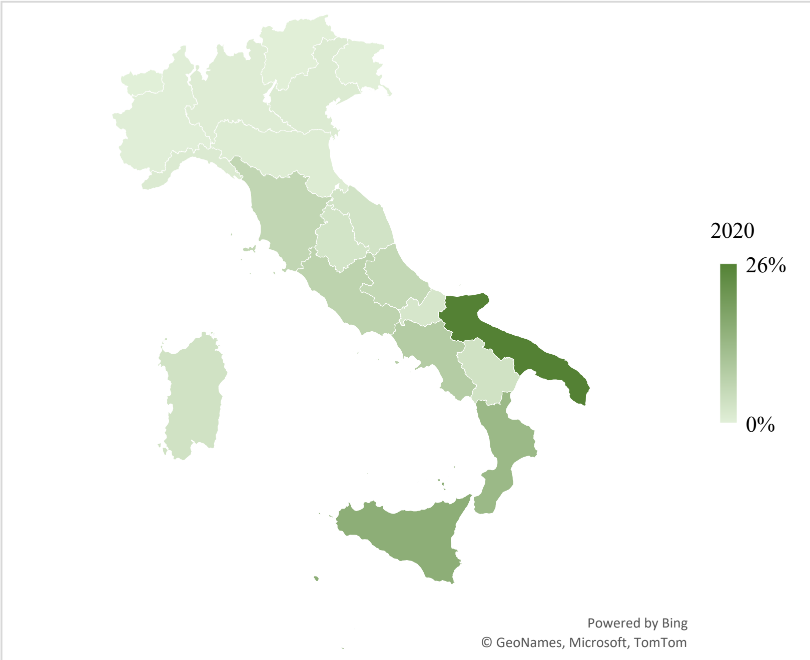

Figure 2-11: Farms working in the olive oil sector (2020) (ISMEA, 2023)

While the cultivated area with olive trees remained quite stable in 10 years (2010-2020), on the other hand, the number of olive oil companies decreased by 31% as average. The highest reduction was booked for Liguria -44%, Campania -40%, Lazio -39%, Basilicata -38%, Abruzzo -37%, Sardegna -35% and other regions with almost 30% of reduction including Toscana, Umbria, Marche, Molise, Puglia, Calabria and Sicilia. On the other hand, some regions showed a relevant increase in this number: Piemonte +202%, passing from 641 to 1,939 olive oil farms, Lombardia 132%, from 1,939 to 4,506, Friuli-Venezia Giulia +61%, from 517 to 832, Valle d'Aosta +51%, from 47 to 71, Trentino Alto Adige +25%, from 845 to 1,056 and Emilia Romagna +12%, from 4,922 to 5,515 olive oil farms (ISMEA, 2023).

Considering the number of active mills in Italy, in 2021 the total was 4,376. As the figure 2-12 shows, the highest number was located in Puglia with 785 mills (18% of the total), followed by Calabria with 669 (15%) and Sicilia with 564 (13% of the total). In the other regions the values represent less than 10% of the total and the lowest number is associated with the Piemonte regions, with just 5 mills (ISMEA, 2023).

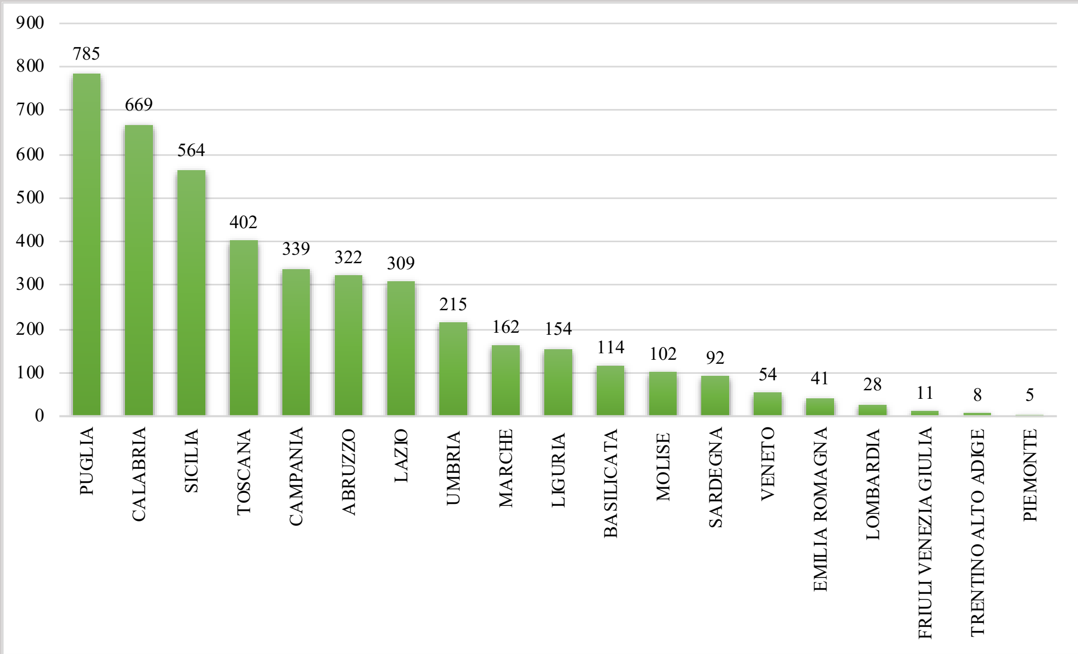

Figure 2-12: Number of active mills in Italy (2021) (ISMEA, 2023)

Comparing the Italian scenario with Spain, in this country the number of mills is lower, between 1,600-1,700 mills but the production is capable to reach almost 1.5 million tons of oil produced (2021). The high number of active mills confirms on one hand the excessive fragmentation, but on the other hand the close distance of the processing plants from the collection sites which favors the quality of the product thanks to the pressing within 24 hours (ISMEA, 2023).

2.2.2 Olive oil productions

Talking about the olive oil produced during the decade 2013-2023, it's clear that the trend is not positive, as the figure 2-13 shows. In the first part of the period (2013-2018) there were many fluctuations, reaching 4.8 million quintals of oil produced as highest value. On the other hand, in the second half the trend was more stable and always around 3.3 million quintals produced, reaching in 2023 3.5 million quintals. Overall, the reduction for the whole period is up to -29% of olive oil produced between the first and the last year (ISTAT, 2024).

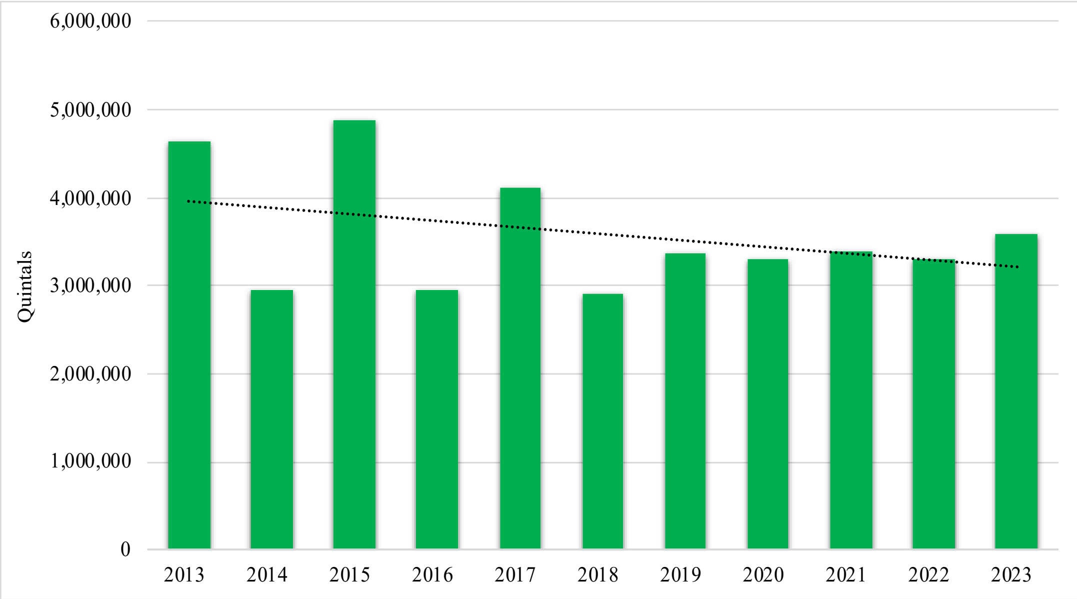

Figure 2-13: Production of olive oil in quintals (2013-2023) (ISTAT, 2024)

Considering in detail the production for each Italian region, data were taken from ISTAT analyzing the production for the year 2023. The first region for the production of the olive oil is Puglia, representing the 35% of the national production with almost 1.3 million quintals produced. Then Calabria with 28% of the total (1 million quintals), Sicily with 12% (428,000 quintals). Just these 3 regions cover the 75% of the national production. All the other regions together cover the remaining 25% of the total, including the Marche region with a production of almost 12,000 quintals (1%). (ISTAT, 2024) (Figure 2-14).

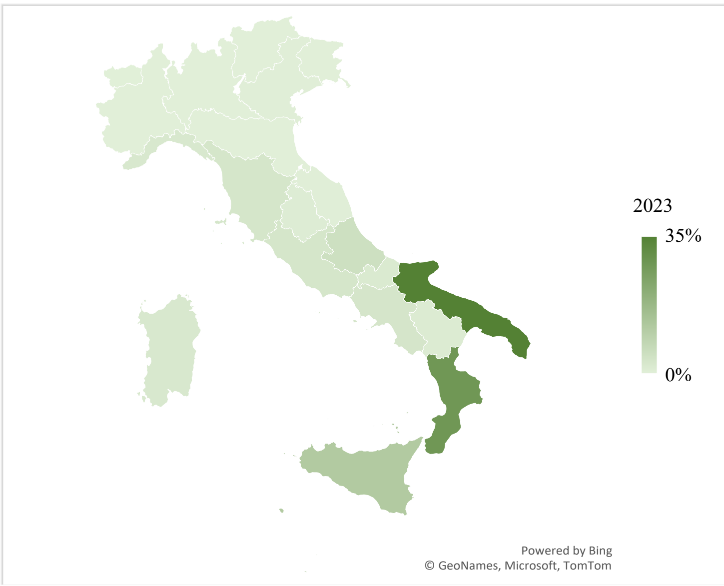

Figure 2-14: Production of olive oil in quintals (ISTAT, 2024)

For Italy an important role is played by the production of the IG oils. Figure 2-15 shows the national production of IG oil from 2010-2021. The last year represents the highest production in tons, being 13,300. In 2018, the value was quite high, with 12,500 tons produced, while in the other years, the amount was around 10,000 tons. Between 2021 and 2010, the last and first year considered, the difference is +28% of IG oils produced. (ISMEA, 2023).

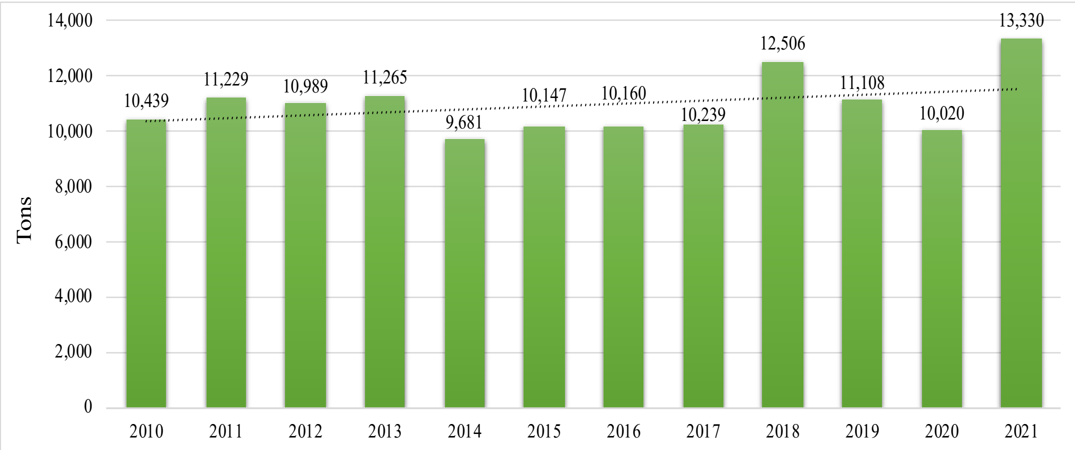

Figure 2-15:Production of IG oil (tons) (2010-2021) (ISMEA, 2023)

In Italy there are 49 IG olive oils being produced, of which 42 have the DOP mark and 7 the GPI. Considering the 2021, as last year with data available, 13,330 tons oil DOP/GPI were produced. Comparing this value with the other two main European producers, Spain and Greece, they both have 29 IG oils. As average the production of IG oils represents just the 2-4% of the national production, it remains at a few thousand tons despite the high number of awards, thanks to an ampelographic scenario which is unique in the world and thanks to the presence of qualified territories and companies of excellence. IG oil remains a niche product without capturing significant market shares. In many cases, however, the market price of some IGs does not differ so much from the price of conventional oil of the same areas and this is not particularly incentive for producers. The value of production in Italy is highly focused on few products. In 2021 this value was around 91 million euros, with Toscana PGI representing the 30%, followed by 22% of Terra di Bari PDO. Then the other IG oils represented less than 10% of the total value (ISMEA, 2023) (Figure 2-16).

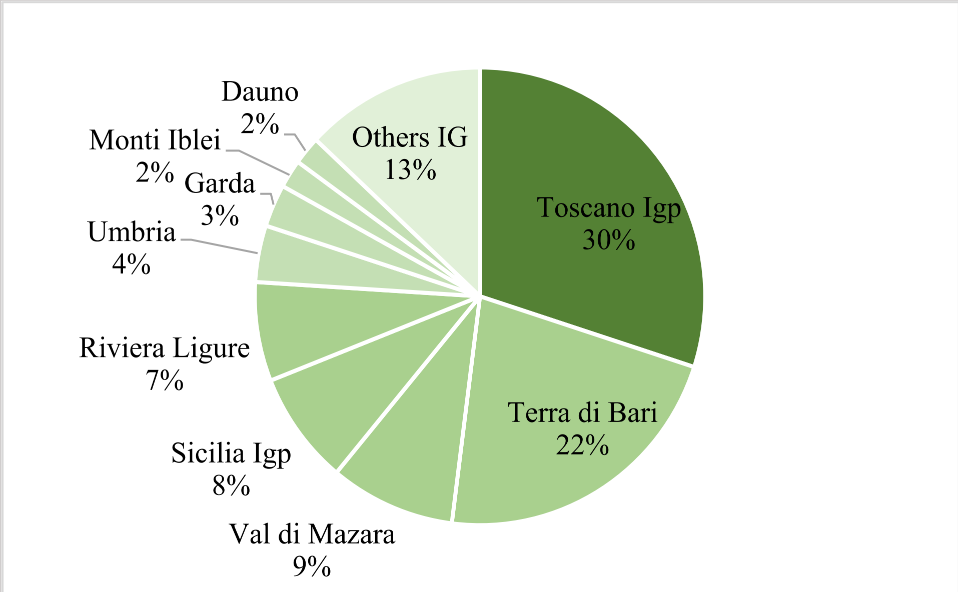

Figure 2-16: Value of production of IG oils (2021) (ISMEA, 2023)

The prices of IG oils in 2022 did not show a uniform trend parallel to what happened for conventional oils. In the south, where there has been a higher production, prices have fallen, while in the north center they have risen. It should be remark that in some areas the price of IG oils does not reach prices too far from conventional oils of the same area and this does not allow to valorize the quality mark. In recent years, thanks to the success of the Toscano PGI, some regional PGI have been recognized and are beginning to gain market recognition, like the Sicilian PGI. In details for the most important IG oils, considering the period 2019-2022, the highest average price was for the *Gard*a with a value of almost 15€/kg as average, followed by *Riviera Ligure* with 11€/kg, *Monti Ibei* with 9.4€/kg, *Umbria* with 8.6€/kg and *Toscana GPI* with 8.2 €/kg (ISMEA, 2023) (Figure 2-17).

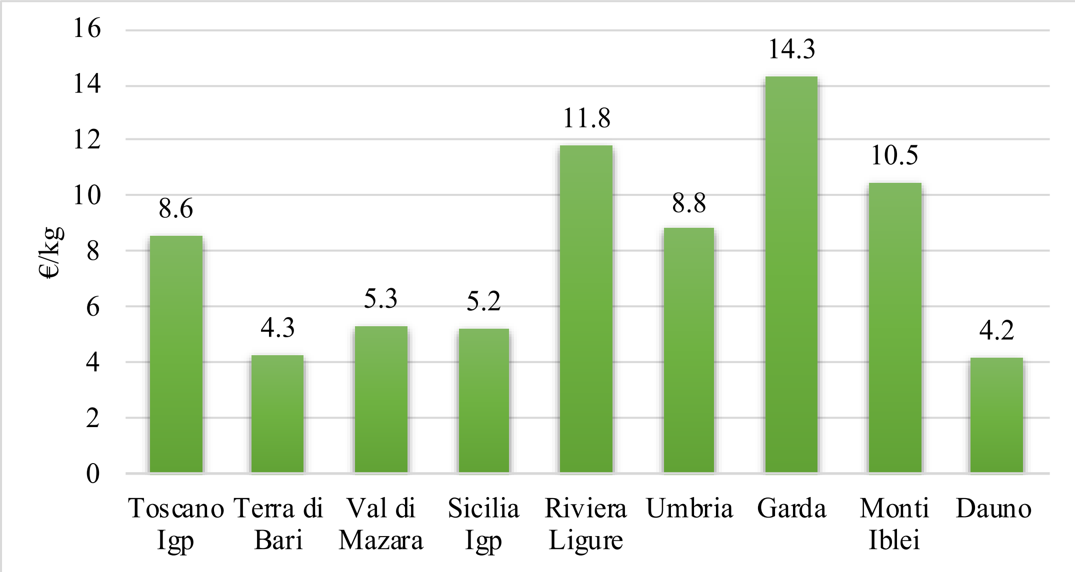

Figure 2-17: Average Prices of IG oils (2022) (ISMEA, 2023)

As the figure 2-18 shows, after 5 years of a huge increase in the organic land dedicated to the production of the olives, after 2018 there was a limited but constant growth. Taking the last year (2021) and the first one (2012) the difference booked is +50% of organic hectares of olive trees. As seen before, also for this aspect the region with the highest value was Puglia with 71,312 Ha in 2021 (30% of the total), strictly followed by Calabria with 69,862 (28% of the total). With a certain distance at the third place there was Sicily with 28,667 Ha (15%) and then Toscana with 25,350 (8%). All the other regions together have a number of organic Ha of olive trees that represented the 19% of the total. The value for Italy in 2021 was 247,541 organic hectares, despite 164,487 in 2012, showing an increase of +50% (ISMEA, 2023).

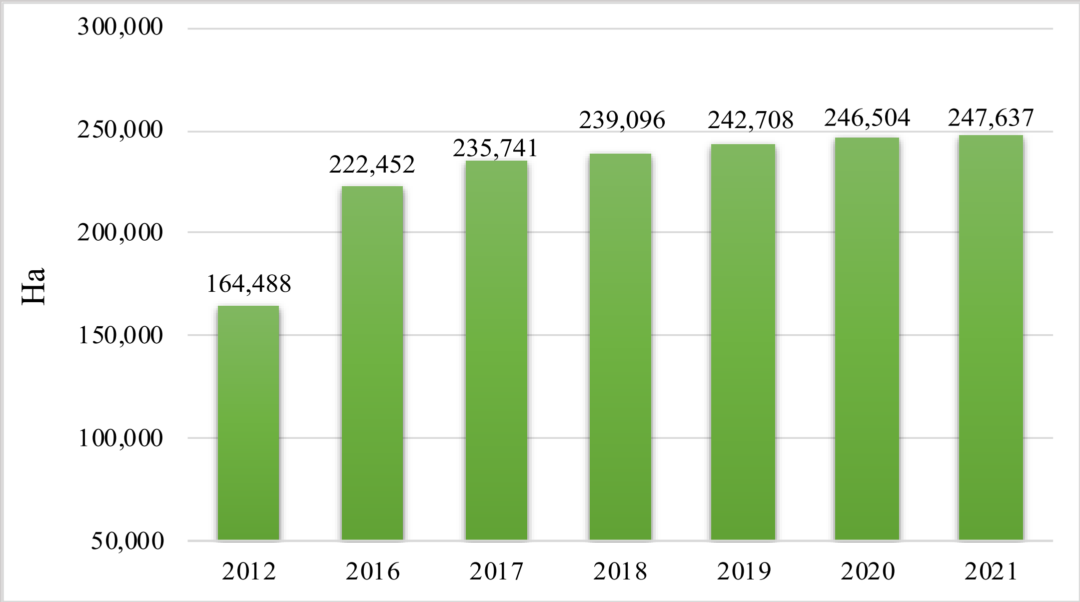

Figure 2-18: Hectares of organic land with olives (2012-2021) (ISMEA, 2023)

Despite 28% of the total surface (1,156,343 Ha) used for the cultivation of olive trees is organic (329,026 Ha), the production of the organic oil is still around 14%: in 2021 the amount of organic olive oil produced was 45,116 tons with 329,026 tons of total olive oil produced. Even in this case the 48% of the production is obtained in Puglia (21,576 tons), followed by Calabria 32% and Sicily with 11%. In the other regions the production of the organic olive oil is really limited, and they totally represent the 9% of the total (ISMEA, 2023) (Figure 2-19).

Figure 2-19: Organic olive oil production (tons, 2021) (ISMEA, 2023)

2.2.3 *Export and import*

For the period 2011-2021 the values for the import and the export are analyzed. In the first year the amount of oil being imported was 625,000 tons and in the 2013 the amount registered a -20%, going just below 500,000 tons. In the next year (2014) there was an increase of +38% and the value reached 666,000 tons. As the figure 2.20 shows, for the export the values were more stable, remaining always around 400k tons during the first years, with a reduction in the 2017 of -17% (332,000). Then after three years at this level, in 2020 there was an increase of +22%, stabilizing at 400,000 tons in 2021. Considering all the period the balance between the amount of oil being imported and exported is negative, always in favor of the import, showing higher number of tons (ISMEA, 2023) (Figure 2-20).

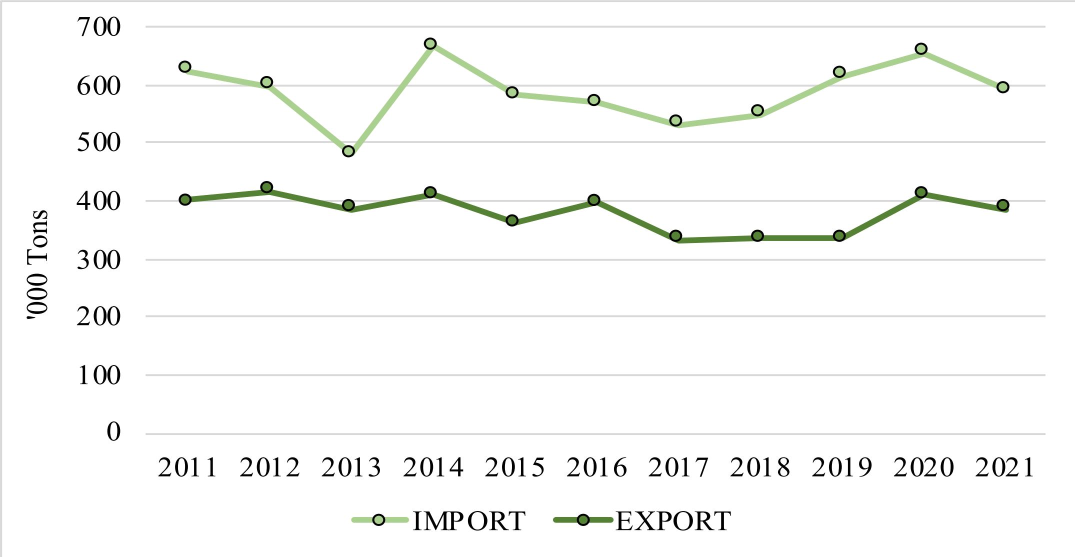

Figure 2-20: Amount of import and export (thousands of tons) (2011-2021) (ISMEA, 2023)

For the same period the value for the import and the export are analyzed, in this case as million euros. The years in which the balance is in favor of the export are the first three (considering the difference between import and export the values respectively being 28 million euros in 2011, 116 in 2012 and 151 in 2013). For all the other year the balance is always in favor of the import, except for the 2020 in which the difference was positive and up to 84 million euros. (ISMEA, 2023) (Figure 2-21).

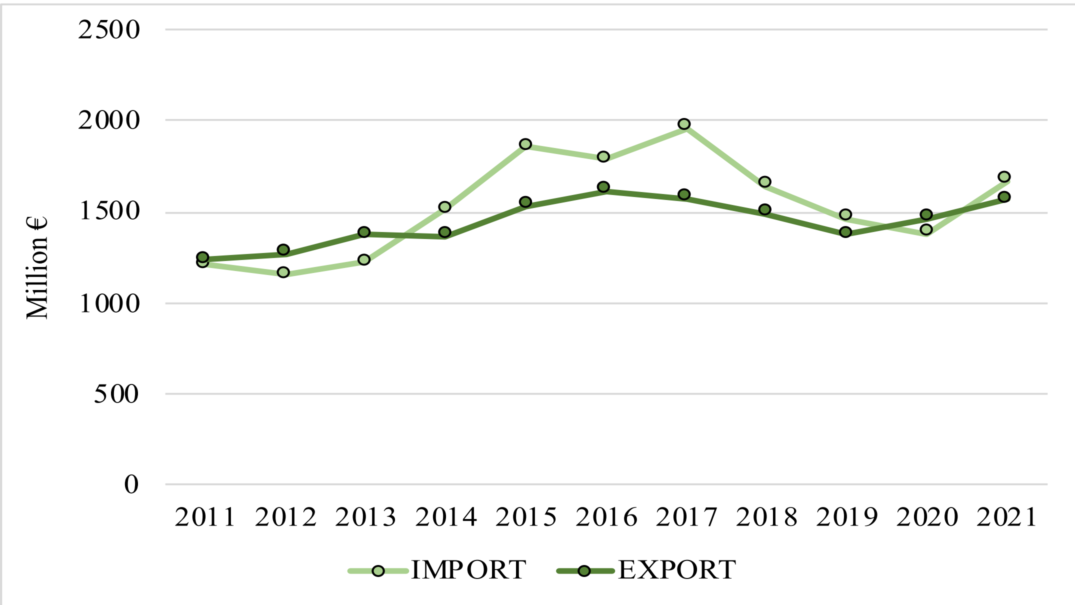

Figure 2-21: Value of import and export (Euros) (ISMEA, 2023)

The figure 2-22 shows the trend for the 2024, on monthly based, of the average price for the EVO oil, considered at the origin (€/kg). Even if there were fluctuations for this value, especially a decrease in November ’23 where the price went down 9 €, the overall trend shows an increase in the price, booking as average for the 2024, until July, a price of 9 €/kg, with a +31% growth in its price, considering the difference between the last and the first month (ISMEA, 2024).

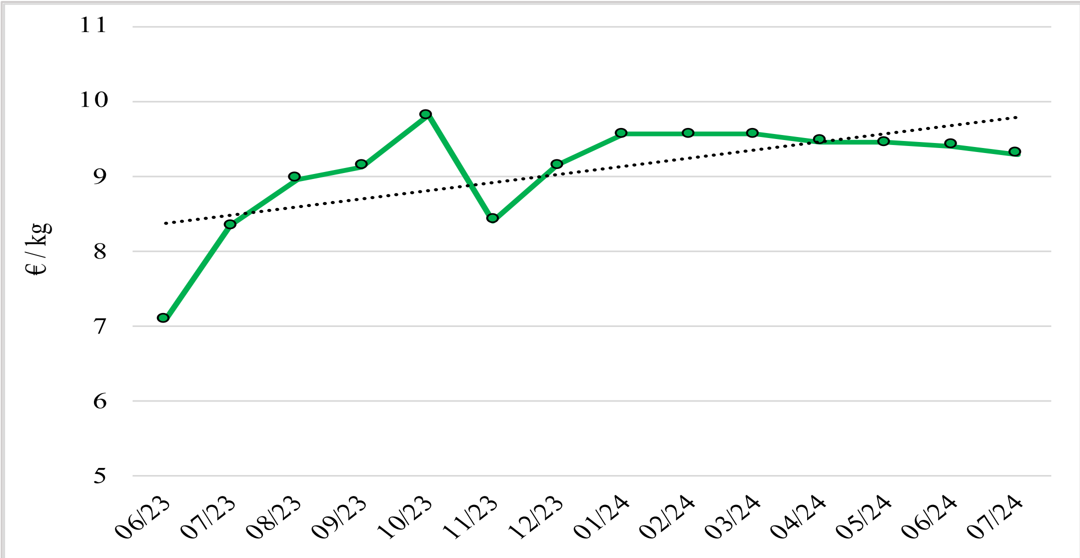

Figure 2-22: Price trend for EVO oil, monthly based (2024) (ISMEA, 2024)

On the other hand, the figure 2-23 explains the trend for the 2024 on monthly based of the average price for the EVO oil from abroad (€/kg). Even in this case in 2024 until July there were fluctuations in the price, at November ’23, April ’24 and July ’24, but the overall trend shows an increase in the price, booking as average a price of 8 €/kg, with a +17% considering the last and first month. (ISMEA, 2024)

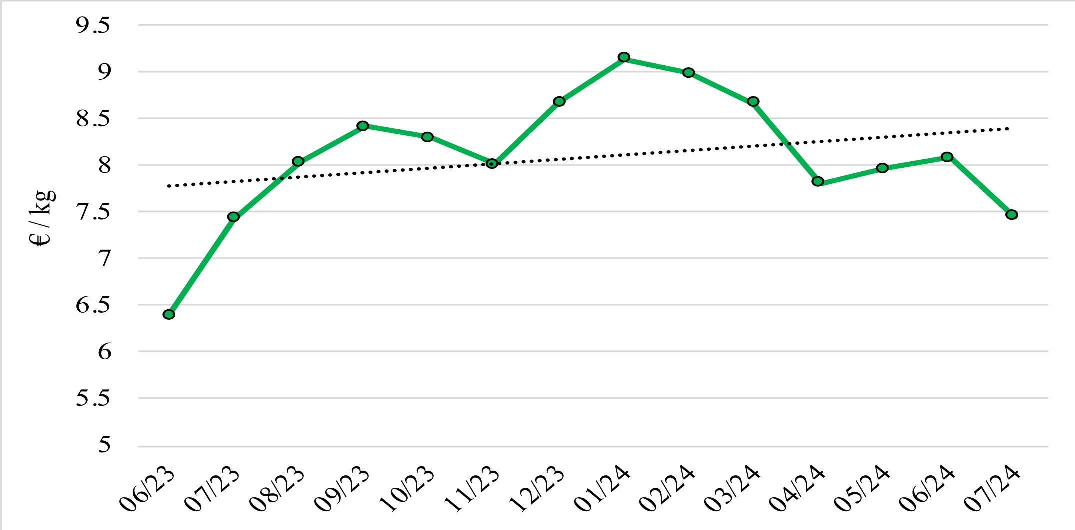

Figure 2-23: Average prices of EVO oil from abroad (2024) (ISMEA, 2024)

The figure 2-24 shows the comparison between the EVO oil's prices at the origin and from abroad in one year, between July 2023 and July 2024. For the period considered the price for the oil at the origin was always higher, showing an average of 9 €/kg. For the same period, considering the oil from abroad, the average was 8 €/kg. The overall trends were similar, but considering the difference between them, it was wider in the first months of 2023 being around 10%, decreasing at the end of 2023 and the beginning of 2024 (around 5%). The highest difference was in July 2024 where the two prices had a difference of 20%, with the highest price related to the EVO oil at the origin, with 9.29 €/kg and for the one from abroad 7.45 €/kg.

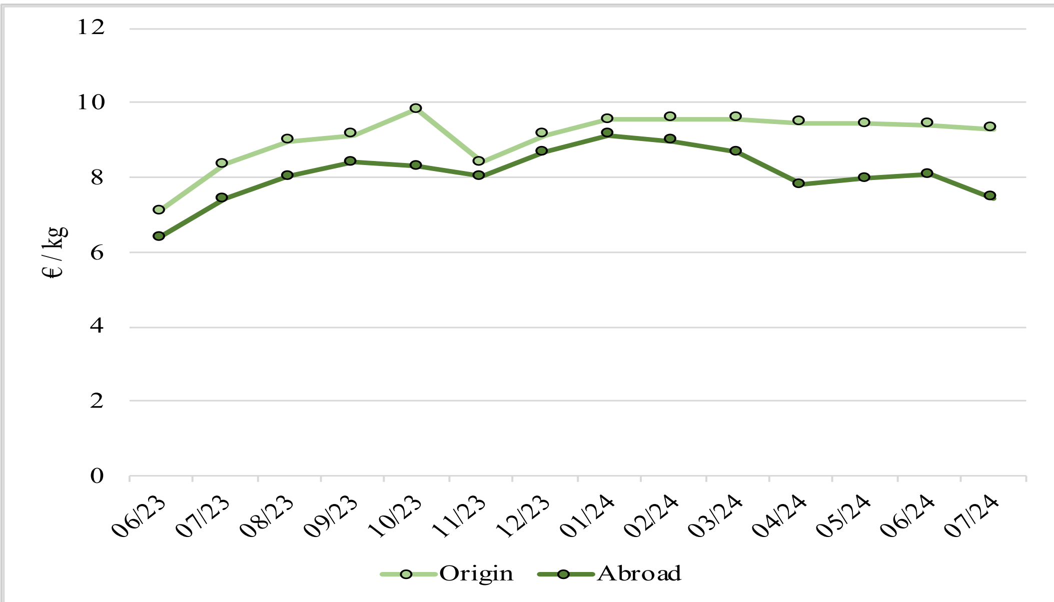

Figure 2-24: Comparison of EVO oil's prices (2024) (ISMEA, 2024)

CHAPTER 3
CASE STUDY: THE PROPENSITY OF PRODUCERS IN THE EXTRA VIRGIN OLIVE OIL (EVOO) CHAIN TO ADOPT BLOCKCHAIN TECHNOLOGY

3.1 Application of blockchain in the agri-food sector

The reason for turning to this blockchain technology lies in its intrinsic ability to make the data it contains essentially immutable, and in the impossibility for agents outside the operators of the distributed platform, on which the blockchain is based, to act on such data. Based on this characteristic, it represents a particularly efficient certification system for the archiving of data relating to production processes, since once entered they are no longer manipulable, thanks to cryptographic hashing; technologies based on distributed registers, therefore, meet the needs of certainty, transparency and traceability necessary for end consumers to have full knowledge of the characteristics and 'history' of the product purchased (UNIPR, 2023). This because stakeholders in the agri-food supply chain may intentionally or unintentionally alter the food distribution process, through adulteration, dilution, tampering, or counterfeiting, compromising the quality and safety of food. Food fraud results in damages of up to $40 billion annually at global level. Worse, the source of the problem is often not easily identifiable. The inefficiencies in conducting traceback investigations reduces public trust in food safety. According to a study, merely 20% of global consumers placed complete trust in companies to ensure food safety. These issues underline the common challenge of ensuring traceability in agri-food supply chains. Defined by the International Organization for Standardization (ISO) as “the ability to follow the movement of a feed or food through specified stage(s) of production, processing, and distribution”, traceability enables the efficient retrieval of key information on an agri-food commodity as it passes along the supply chain. Enhancing traceability can enable increased visibility on working conditions, monitoring of environmental impact of agri-food production, capability to track development outcomes, and improved public health outcomes. The importance of traceability is being recognised by diverse actors in agri-food supply chains, including regulators, corporations, and consumers.

Over 71% of consumers around the world are willing to pay a premium for brands that provide transparent information (UNDP, 2021).

The olive oil, together with the wine, represent the agri-food product most controlled in Italy, because is also one of the most exposed sectors to frauds (Olivonews, 2024). In Europe in the first trimester of the 2024 there were 50 suspicious cases, with the Italy having the highest number of alerts. In the previous year, 2023, there were 8,673 controls on 5,270 operators, with 16.7% of them being irregular. Talking about products, 9,504 were checked and the 12% was irregular. This led to the confiscation of more than 3 million kg for a total commercial value around 15 million € of olive oil. Among the main illegal acts they found: extra virgin olive oil below the category of chemical and/or organoleptic analysis or obtained mixing it with seed oil; violations of labelling rules; irregular use of optional indications; the failure to keep electronic registers of olive oils or their incorrect keeping; the failure to indicate the geographical origin in extra virgin olive oil (Olivonews, 2024).

So it is clear the potential that a tool like this can have. Project managers considering incorporation of blockchain technology in agri-food supply chains might be interested in popular blockchains already available. *Ethereum* and *Hyperledger Fabric* are example of type of blockchain for organisational usage and serves as a baseline for comparison between different blockchain technologies. *Ethereum* is an open software platform with permissionless blockchain network optimised for smart contracts that uses its own cryptocurrency called *Ether*. It allows anyone to personalise their smart contracts that is connected to the *Ethereum* blockchain for validation by public nodes. *Hyperledger Fabric* is an open-source project from the Linux Foundation supporting enterprise blockchain platforms. It has advanced privacy controls for permissioned blockchains which shares data and participation rights with specified and authorised stakeholders only. A 2021 study of UNDP (United Nations Development Programme) about 80 projects in agri-food supply chains found that 19 % of blockchain projects adopted *Ethereum* while 10 % used *Hyperledger Fabric*. Noting that 47 % of the projects did not reveal any information about their blockchain-based solutions, the finding is instructive of the dominance of these two blockchain architectures. Between *Ethereum* and *Hyperledger*, project developers who hope to protect the private nature of transactional relationships may prefer *Hyperledger*. The ‘channels’ feature in *Hyperledger Fabric* allows for total transaction isolation, while the ‘private data’ feature keeps data private while sharing hashes as transaction evidence. Project managers in the agri-food sector may also be interested in readily available solutions and the future development trends in blockchain technology. Blockchain-as-a-solution (BaaS) is an increasingly popular service where companies can share existing blockchain infrastructure with monthly or annual service fees. Currently, some ERP (Enterprise Resource Planning) software companies like *SAP* and *Oracle* are moving up their value chain to develop the middleware technologies required to achieve synergy between existing ERP systems and blockchain networks. Many ongoing BaaS trials focus on supply chain management and provenance checks. These solution providers have mostly adopted a model of offering blockchain services on cloud platforms to companies that want to employ blockchain but find it difficult due to high barriers to entry including high upfront costs and the unavailability of technical expertise. BaaS clients may also benefit from complementary consultation services offered by solution providers, ensuring the suitable employment of blockchain features to meet their needs. With rapid advances in multiple frontiers of the technology, new developments will be closely monitored by BaaS providers. The following table provides an objective and a comparison between existing BaaS providers (UNDP, 2021) (Figure 3-1).

	SAP	ORACLE	aws	IBM
Hosting platforms	Hyperledger Fabric	Hyperledger Fabric	Hyperledger Fabric Ethereum Quorum Corda	Hyperledger Fabric
Blockchain type	Permissionless	Permissioned, Consortium	Permissioned	Permissioned
Authentication and authorisation services	–	Pay per use	Pay per use	Monthly subscription with free trial
Scalability	–	–	Provides API for quick node creation	IBM Smart Cloud only

Figure 3-1: Blockchain as a service provider (UNDP, 2021)

The unique aspects of blockchain technology, particularly transparency and immutability, can address issues related to income inequity, environmental degradation, human rights violations, and food safety in agri-food supply chains. By leveraging accessory technologies, agri-food characteristics of interests can be tracked digitally through the supply chain, enabling quick identification and remedy of problems. The promise of blockchain technology and the relative ease of its application may appeal to project managers working in the agri-food sector (UNDP, 2021).

Due to the absence of coordination mechanisms for the various projects that have arisen "spontaneously" over the years, the framework of blockchain platforms in Italy is currently extremely fragmented, as there are numerous platforms, in addition to the now well-known "Bitcoin" and "Ethereum", with structures and characteristics that are also very different from each other and not always able to guarantee the security of the data recorded within them (UNIPR, 2023).

As previously said, the olive oil represents one of the agri-food products most exposed to frauds, for which the application of the blockchain technology appears very promising. For this reason, the next paragraph 3.2 is focused on the description of a statistical methodology that aims to understand the intention in adopting the blockchain technology and the willingness to pay for it by Italian producers of evo oil.

3.2 Methodology

In this paragraph the goal is to describe the various stages of the methodological process applied in this research. The analysis was performed using a survey-based approach with an online questionnaire for collecting the data. With this, a series of information was collected and after detailed analysis, it was crucial for a deeper understanding and interpretation of the intention of the olive oil producers in adopting the blockchain technology and the willingness to pay for it, as digital traceability system, to increase their competitiveness both at national and global level. In fact, this thesis is framed in the work of the 2020 Research Project of Relevant National Interest (PRIN) of the Italian Ministry of Universities and Research (MUR) named "WEBEST—Wine EVOO Blockchain Et Smart Contract" (Prot. 020LMWF9Y). The project aims to develop and implement the blockchain technology for the protection of the "Made in Italy" extra-virgin olive oil and wine.

The survey used appears extremely relevant, also considering the Italian Law 206/2023 (entry into force on the 11th of January 2024) which has the objective of reinforce the strategic supply chains of the *Made in Italy*, through the use of the digital technologies, including the valorization of the extra virgin olive oil. The data of the survey were collected, checked and organized in a database to carry out subsequent processing. In particular, the study carried out has two main objectives:

- Investigate the factors that influence olive oil's producers towards the adoption of the blockchain technology.
- Estimate the willingness to pay for the blockchain service.

3.2.1 Questionnaire design

The questionnaire mainly contains closed-ended questions and some open-ended questions (it could be found in Annex 1). It was made in Italian, because the goal was to spread it between the Italian producers of olive oil and contains a total of 29 questions, starting with a short description of its purpose. After these, 5 sections are present:

1- Technical and economic structure of the company interviewed
2- Level of digitalization of the farmer and of the company
3- Blockchain's knowledge, definition and intention to adopt
4- Willingness to pay for the blockchain
5- General information about the company and the interviewed.

The survey starts with a single question, given to the person being interviewed, asking if he/she agree in being part of the study by filling the questionnaire. This question was used as a filter question in the sample selection.

SECTION 1

The first section aims to understand the economic and technical structure of the company, asking the type of activity applied, if the company produces and mills the olives of its property, or if it just produces the olives, milling them in another company, if it mills the olives without producing them, if it just produces the olives or if it's a packaging company. After this, with a direct question, the survey asks if the company directly market the olive oil.

SECTION 2

In this section the aim is to indicate, with an agreement scale from 1 to 5 (where 1 completely disagree, 2 disagree, 3 undecided, 4 agree, 5 completely agree) the degree of agreement/disagreement to some sentences, related to the inclination of the interviewed in using technologies, especially the new one, and the effects that it has on his/her life. After having identified the level of personal digitalization, a number of questions were put in this section, on how much the interviewed consider its company digitalized, with a scale from 1 to 5, where 1 indicates very little (company uses just e-mails and WhatsApp) and 5 excellent (company applies precision agriculture and industry's solutions 4.0).

SECTION 3

In this section, with a dummy question, the survey asks if the interviewed ever heard about the blockchain technology, as a tool to ensure the origin and traceability of products, specifying the use of blockchain for the valorization of the olive oil. After this question, the definition of blockchain is provided, indicating it as "a computer/digital service that allows the company to record the path of its products (even just one) from field to table, along the entire supply chain. This allows the entire oil path to be traced, ensuring transparency, data integrity and confirmation of its identity. Once the product data has been recorded, the system can create a digital label (QR code) with which the consumer can track the product and view the supply chain story. It is a system which protects both the producer and the consumer."

The definition was provided to validate the level of knowledge of the sample and allow respondents to answer the questions that followed.

Once the definition was provided, the willingness to adopt the blockchain was analyzed. Using an agreement scale from 1 to 5, (where 1 completely disagree, 2 disagree, 3 undecided, 4 agree, 5 completely agree), as the one for the section 2, a series of questions are asked. The scale will be discussed in detail in paragraph 3.3.5

SECTION 4

In this section the survey wants to understand the willingness to pay for this service, specifying that for the traceability of one or more products of the company through blockchain it is possible to pay for an annual subscription service, which offers:

- The blockchain recording of data relating to the various stages of the supply chain
- Digital data validation
- Sharing of data with both business partners and the end consumer through digital labels
- Creation of a dedicated web page for the consultation of supply chain data
- The protection of the data uploaded online
- Assistance and maintenance of a third-party employee

Then it is specified that the annual service charge is a flat rate and therefore independent of the final quantity of products marketed. The willingness to pay was determined by using the contingent valuation method with dichotomous choice. This was originally developed in environmental economics (Randall et al., 1990) but it is well suited to soliciting users' WTP for a product that is not yet on the market (De Groote et al., 2008) and it is often preferred over other methods, such as experimental markets, for its flexibility and limited costs (Boccaletti et al., 2008). In fact, there are many examples in the literature which use CVM to estimate the importance for consumers of indicating the product's origin, quality certifications, or a particular method of production (organic) indicated on the label. The contingent valuation consists of creating a hypothetical market for a non-market good in which the consumer expresses the WTP for buying it, which corresponds to the utility derived from its consumption (Loureiro et al., 2003).

The first offer was therefore proposed to the respondents of 2000 €. In case of acceptance a second offer at an increased price (3000 €) was given, in case of refusal a second offer at a lower price (1000 €). In case of refusal to both price proposals the survey asks for what reasons he or she is not interested to access the proposed service, selecting 3 possible options.

SECTION 5

The last section of the survey aims to collect general information about the company, where it is located, the types of production, the products that he/she wants to valorize through blockchain, the hectares of olive trees, types of milling and extraction applied, the quantity of olive oil packaged each year, percentages of sale on the regional, national, foreign market and the main channels used for the selling (direct sale, GDO, E-commerce, Ho.Re.Ca or through intermediaries).

Moreover, general information about the interviewed, like age, gender and the education degree were collected.

3.2.2 Sampling and data collection

The data collection was carried out in the period from May to October 2024, through the use of an online questionnaire, designed and administered to a sample of 113 producers. They were reached using two olive oil producer's associations, Unaprol at national level and Aprol Marche*,* at local level. The questionnaire was designed by using the software called "Google Forms", available online. The use of an online survey brings with it numerous advantages such as the speed of diffusion, the ease of creating the database with the answers, and the ease of processing; on the other hand, it makes it impossible to reach people who do not have this technology. A copy of the whole questionnaire is available in the Annex I of this thesis. The questionnaire was anonymous, and the data collected have been processed in compliance with the law on privacy.

3.2.3 Model specification

The model used for the analysis comes from the one of Queiroz et al. (2020), which is based on the UTAUT scale (Unified Theory of Acceptance and Use of Technology). For the BCT technology this scale has been widely applied in different sectors to understand the factors that influence its adoption (Almekhlafi and Al-Shaibany, 2021). The primary version of UTAUT debates that behavioral intention (BINT) and use behavior are influenced mainly by performance expectancy, effort expectancy, social influence, and facilitating conditions. But evidence supports that not all original assumptions proposed under UTAUT are true in different contexts (Adaryani et al., 2024). For this, Venkatesh et al. (2016) advises that the proposed UTAUT model applied in different contexts can guide to its expansion and improvement. Therefore, following the work of Queiroz et al. (2020) other factors have been added.

The model used by Queiroz et al. (2020) is made of six main constructs: behavioral intention to adopt the system (BINT), effort expectancy (EEXP), facilitating condition (FCON), performance expectancy (PEXP), social influence (SINF) and trust (TRUS), that predict behavioral intention to adopt blockchain. In this study, personal innovativeness (PI) from Kisilingam and Krishna (2020) and willingness to pay (WTPQ) from Shi et al. (2022) are added (Table 3), as other constructs. Each of them is linked to a specific item, which in turn is linked to specific measurement items, adapted for the blockchain. The level of personal innovativeness of individuals plays a significant role in the adoption of new technology and might be a good predictor of intention to adopt blockchain. Moreover, the willingness to pay for a specific product or service might be considered a limiting factor. Therefore, an understanding of olive oil makers' willingness to pay may help more in introducing such technologies in everyday tasks.

Reference	Determinant	Costruct	Item	Measurement items (EN)
Queiroz et al., 2020	Behavioural intention to adopt	*BINT*	BINT1	I intend to use blockchain in the future
			BINT2	I predict I would use blockchain in the future
			BINT3	I plan to use blockchain in the future
	Effort expectancy	*EEXP*	EEXP1	Learning how to use blockchain is easy for me.
			EEXP2	My interaction with blockchain is clear and understandable
			EEXP3	I find blockchain easy to use
			EEXP4	It is easy for me to become skilful in using blockchain.
	Facilitating conditions	*FCON*	FCON1	I have the necessary resources to use blockchain
			FCON2	I have the knowledge necessary to use blockchain
			FCON3	Blockchain is compatible with other technologies I use
			FCON4	I can get help from others when I have difficulties in using blockchain.
	Performance expectancy	*PEXP*	PEXP1	I find blockchain useful in my daily life.
			PEXP2	Using blockchain increases my chances of achieving tasks that are important to me.
			PEXP3	Using blockchain helps me to accomplish tasks more quickly.
			PEXP4	Using blockchain increases my productivity
	Social influence	*SINF*	SINF1	People who are important to me think that I should use blockchain.
			SINF2	People who influence my behaviour think that I should use blockchain.
			SINF3	People whose opinions I value prefer that I use blockchain.
	Trust.	*TRUS*	TRUS1	I believe that blockchain is trustworthy.
			TRUS2	I trust blockchain.
			TRUS3	I have no doubt on blockchain's reliability.
			TRUS4	I feel assured that legal and technological structures adequately protect me from blockchain-related problems.
			TRUS5	Blockchain has the ability to fulfil its task.
Kisilingam and Krishna, 2020	Personal innovativeness	*PI*	PI1	I think I know more about blockchain technology than my circle of friends
			PI2	If I heard about blockachain technology, I would look for ways to experiment with it
			PI3	Among my peers, I will be the first to try blockchain
			PI4	I like to experiment with new technologies, like blockchain
			PI5	I think I will be using blockchain even if I did not know anyone who had used it before
Shi et al., 2022	Willingness to pay	*WTPQ*	WTPQ1	I will use blockchain in agricultural firming, even if the price increases somewhat
			WTPQ2	I am interested to pay a higher price for blockchain than similar agricultural technology
			WTPQ3	I will use blockchain even if the price increases

Table 3: Determinant, construct, items and measurement items

In accordance with the variables incorporated into the model, a series of hypotheses have been formulated.

- *H1: Effort expectancy positively affects the behavioral intention to adopt blockchain,* which represents the degree of ease associated with the use of the blockchain.
- *H2: Facilitating conditions positively affect the behavioral intention to adopt blockchain.* This could be contextualized as the individuals' understanding of the resources (organizational and technical infrastructure) that are available in the company to support the use of blockchain.

- H3: Performance expectancy positively affects the behavioral intention to adopt blockchain. It defines the degree to which individuals perceive that the use of blockchain technology will improve their productivity and performance.
- *H4: Social influence positively affects the behavioral intention to adopt blockchain.* This indicates how people influence the behavior of others to adopt blockchain technology.
- *H5: Trust positively affects the behavioral intention to adopt blockchain.* The trust construct refers to the willingness of a party to be vulnerable to the actions of another party. In detail, it represents the risk of taking a relationship and sharing data (trusting blockchain entails availability and confidence in the information that is shared between the members of the supply chain).
- *H6: Personal innovativeness positively affects the behavioral intention to adopt blockchain.* It defines the disposition to adopt early novelties, including technologies like blockchain.
- *H7: The behavioral intention to adopt blockchain positively affects the willingness to pay for a BCT annual service.* It is defined as the highest price to be willing to pay for a product or service. The willingness to pay is a fundamental variable, as costs of investment and product pricing are crucial in the diffusion of the technology in the market.

The structural model is shown in the figure 3-2.

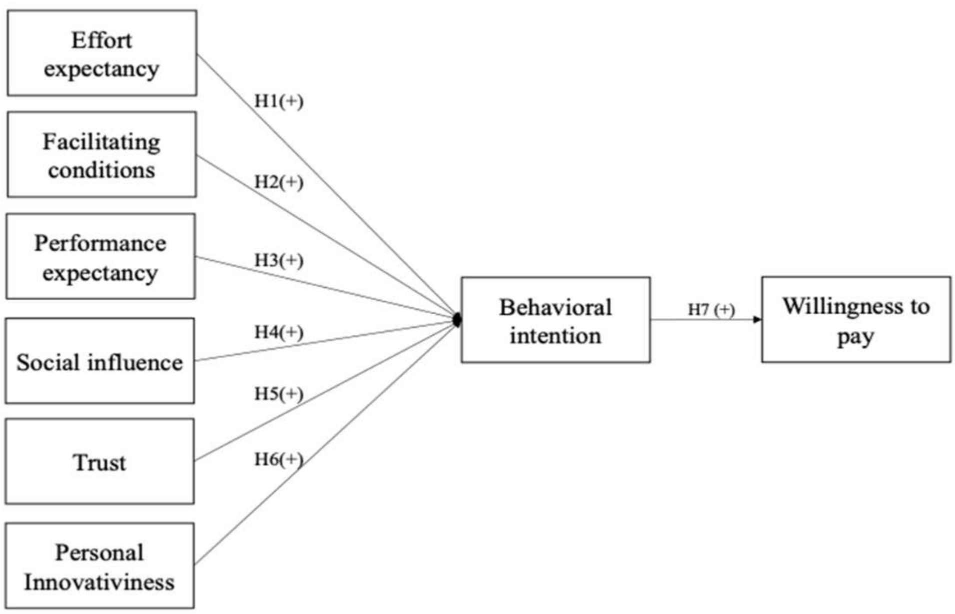

Figure 3-2: Hypothesis used in the model

In this study, for the statistical analysis, we used the Partial Least Squares Structural Equation modeling technique (PLS-SEM). PLS-SEM is an integrated modeling technique that allows researchers to assess the correlations between variables as well as the reliability and validity of any research framework (Hair, et al., 1998). PLS-SEM is useful for both empirical and exploratory studies. Scholars frequently utilize the technique with non-normal data and a small sample size (Guenther, et al., 2023). Furthermore, PLS SEM has been shown to be an appropriate technique for analyzing data on emerging topics, as was the case here when identifying producers' behavior toward blockchain use in the olive oil production. In light of this study's exploratory nature, PLS-SEM appears to be an appropriate strategy. The steps outlined by (Hair, et al., 2019) were followed for data analysis with PLS-SEM to test the hypothesis. The measuring model was first tested for reliability and validity using the metrics Cronbach's alpha (Cronbach L.J., 1951) and average variance extracted (AVE) (Fornell et al., 1981). The structural model was then tested with the 'plssem' package in STATA 15.1 (Venturini & Mehmetoglu, 2019).

3.3 Results and discussion

3.3.1 Socio-demographic characteristics of the sample and farms characteristic's

In this section the main results, obtained from data collected through the online survey questionnaire, are presented and discussed for a descriptive analysis which anticipates the statistical one. The analysis of the data started on the 4 November 2024, date at which the number of answers was 113. Inside this number, 95% agreed in being part of this study, in contrast with 5% of disagreement, giving the final sample of 107 interviewed.

The sample is distributed throughout the national territory, with particular concentration in the Marche region, which represents the 44% of the total. The concentration of the sample in this region is linked to the place of launch of the questionnaire. Other highly represented regions are Sicily with 21% of the sample, Calabria with 15%, 8% in Sardinia and 3% in Basilicata. The other regions cover the remaining 9% of the total, including Lazio, Liguria, Molise, Puglia, Toscana and Umbria. Another variable considered is the type of agriculture that the companies apply. The questionnaire showed that the majority of them apply organic agriculture, with 46% of the sample, followed by a 43% of traditional agriculture and 11% with integrated agriculture (Figure 3-3).

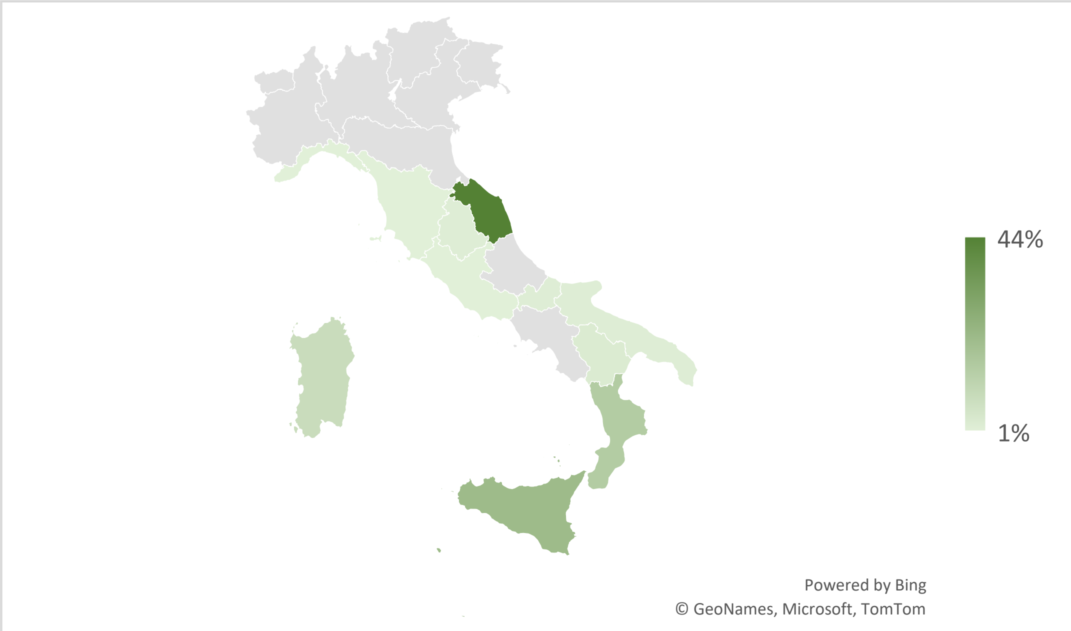

Figure 3-3: Location of the sample

Regarding the socio-demographic characteristics of respondents, 90% was male. 11% of the respondents are between 18 and 35 years old, 48% between 36 and 55 years old and 40% are over 56 years old (1 answer blank). Considering the educational level, 20% of the participants have the primary/mid school level, 51% the high school, 25% the graduation level and just the 4% a post-graduate level (Table 4).

Variables	Categories	
Gender	Male	90%
	Female	10%
Age	18-35 years	11%
	36-55 years	48%
	56+ years	40%
Degree Level	Elementary/Intermediate	20%
	High schools	51%
	Graduation	25%
	Post-graduate (master/PhD)	4%

Table 4: Summary of the socio-demographic characteristics of the sample

Talking about the companies that the interviewed represent, the survey shows that 56% of them are micro companies, 42% are small-medium and 2% big companies. The majority of the sample has a range of hectares of olive trees between 0 and 15 (71%), followed by 13% between 16-50 hectares, 11% between 51-150 and just the 5% which has more than 150 hectares of olive trees. Talking about the types of milling applied in the companies, between who have a mill the 54% applies a milling process based on the 3 phases system, while the 46% on the 2 phases. Talking about the extraction method, just considering the ones with the mill inside, 53% of the sample applies a cold extraction, while the 5% a traditional process (Table 5).

Variables	Categories	
Company	Microcompany	56%
	Small-medium	42%
	Big company	2%
Hectares olive trees	0-15	71%
	16-50	13%
	51-150	11%
	>150	5%
Mill	2 phases	46%
	3 phases	54%
Extraction	Traditional extraction	5%
	Cold extraction	53%
	No mill	40%
	Other	2%

Table 5: Summary of the socio-demographic characteristics of the companies

Regarding the kind of activity that the company does. More than half of the sample, up to 59%, are producers of olives but the milling step is applied in external companies. Just the 26% of the interviewed apply the milling inside the company. The 10% of the sample are just producers of olives, 3% applies only the milling step without the cultivation of olives, and the remaining 2% are packager companies (Figure 3-4).

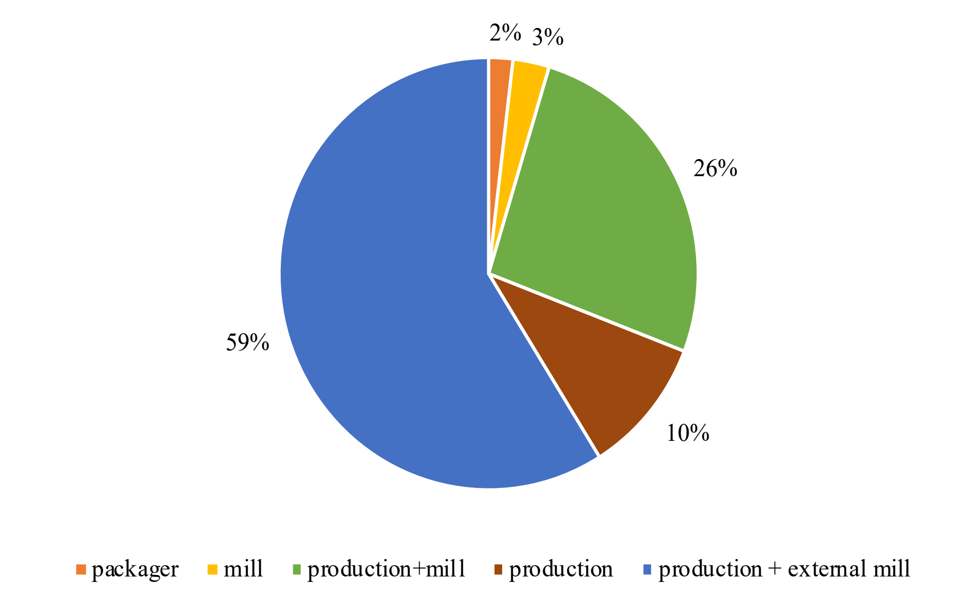

Figure 3-4: Economic and technical nature of the sample

After this the survey asked if the company directly applies the marketing of the olive oil, and out of 107 samples, the 69% answered yes, while the 31% answered no (Figure 3-5).

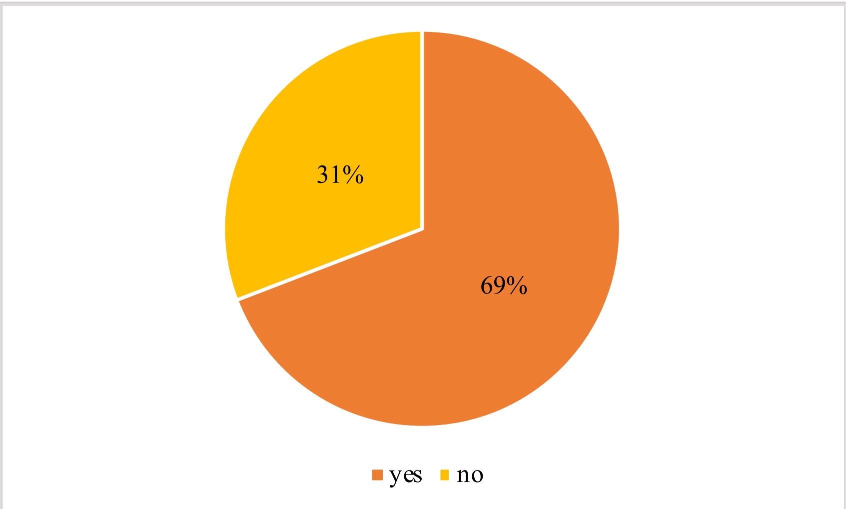

Figure 3-5: Do you directly market the olive oil?

For the main types of selling, most of the companies apply direct selling, specifically the 59% of the sample. Then the second way of selling, based on its importance, it is related to the use of intermediaries (16%). Then E-commerce comes, as third types, used by the 11% of the companies. After these, whit lower percentages, there is the selling of products into the Ho.Re.Ca, through Great Organized Distribution (GDO) and a small portion of the sample which takes its product for a family/private use.

Lastly, talking about export, just the 22% of the sample exports its products, leaving the 83% of them that don't do it. The main countries to which the products are sent are other European States, then USA and Asia.

The previous data taken from the survey can provide a wide range of information that could helps to better understand the characteristics of the companies interviewed, their way of working and management of the activities. This allows a segmentation that can reveal significant differences in perceptions and practices between different companies. Furthermore, the collection of socio-demographic data can reveal any disparities in access to information on the blockchain system and its adoption, if there are. This information can then guide efforts to make information related to the blockchain more accessible and inclusive.

3.3.2 Level of digitalization and scales descriptive statistics

In section 2 it was asked to indicate, using an agreement scale (where 1 Completely Disagree, 2 Disagree, 3 Undecided, 4 Agree and 5 Completely Agree), the degree of agreement/disagreement with some sentences. These questions are based on the ATAS (Abbreviated Technology Anxiety Scale), a scale that allows to define the level of digitization of the interviewed. In particular, ATAS results are negatively correlated with frequency of use, self-efficacy and attitudes towards technology (Wilson et al., 2023).

From all the answers, considering a minimum score of 5 and a maximum score of 50 an average of all of them was taken, and the result is up to 21.52, in the middle but closer to the disagree level. The sentences were structured referring to the technologies is a negative way, so the average result shows that the majority of the sample finds the technologies useful for their life.

In detail, considering the percentages of their answers, it came out that 46.7% of the sample feels itself non anxious and always 46.7% are moderately anxious in using technology. The remaining percentage, up to 6.5%, perceive themselves very anxious in it (Figure 3-6).

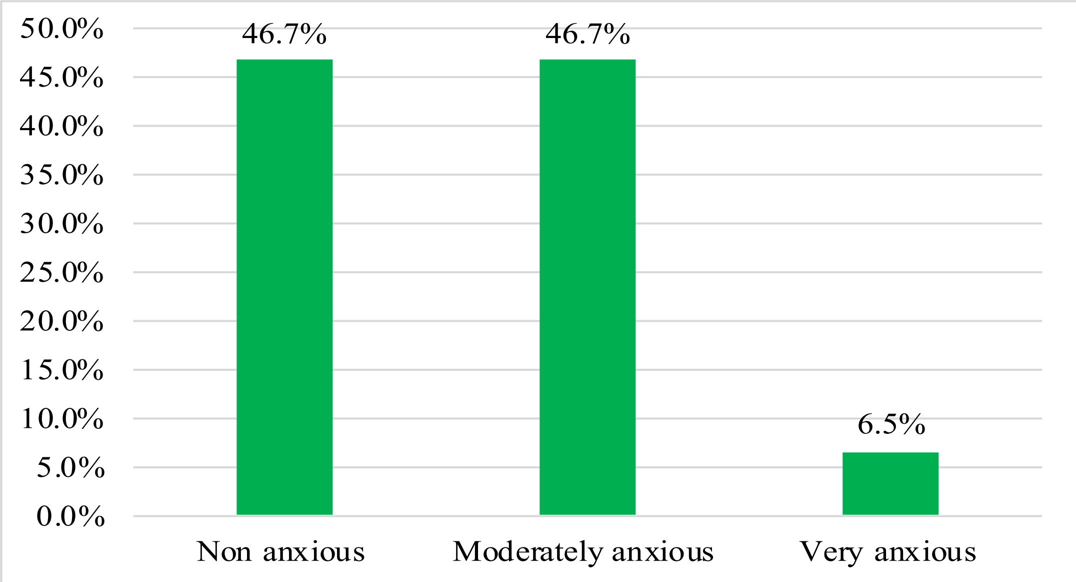

Figure 3-6: Anxiety in using technology (ATAS scale)

In the same section we also asked how much the interviewee considers his company digitalized, giving an example. If the company uses only e-mail and WhatsApp is little digitalized; the company is excellent if applies precision agriculture and industry solutions 4.0. The average of the answers was taken, being up to 2.7, showing that the degree of digitalization of the sample companies is not that high. In detail Figure 3-7 shows the percentages for the answers grouped by category. 33% of the samples consider its company digitalized at the average level, followed by 23% that think it is below the average. 21% considers is company very low digitalized. On the other hand, 17% of the interviewed considers it company above the average as degree of digitalization and just the 7% think that its company is excellent considering the degree of digitalization.

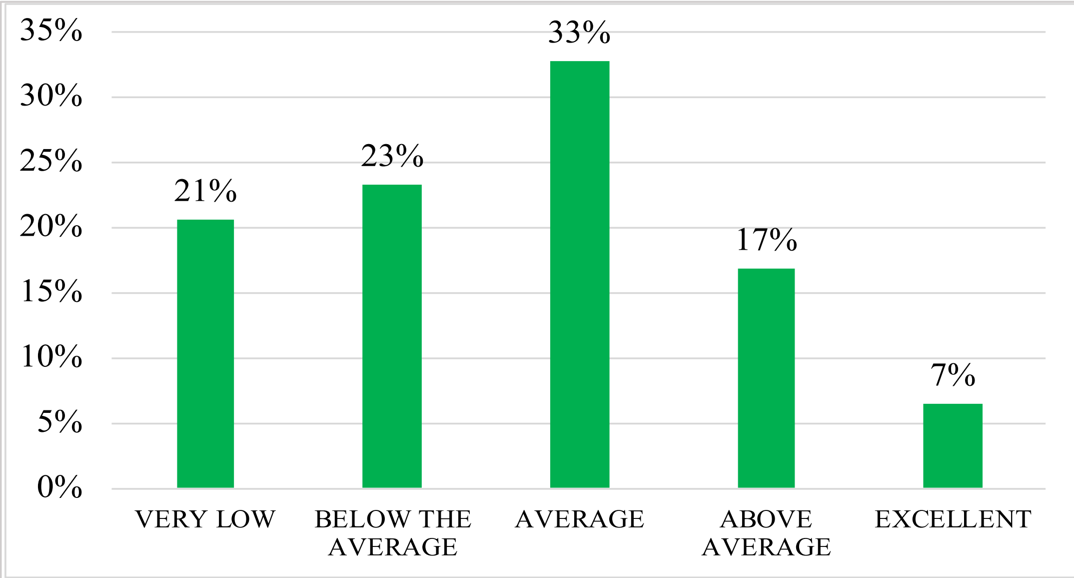

Figure 3-7: Degree of digitalization of the companies

So, it came out that the interviewed, as persons, are mostly non anxious and, at the same level, moderately anxious in using technology. While talking about their company the data shows that most of the companies are between the average, or below, as digitalization level, showing a mismatch between the two results.

After asking the degree of digitalization of the interviewed and of the company, with the next section the survey goes in detail for getting information specifically about the blockchain.

3.3.3 Knowledge of blockchain

A specific question was asked trying to understand if the interviewed have ever heard about blockchain. The result is that more than half of the sample, up to 57% have never heard about this technology, while the 43% yes (Figure 3-8).

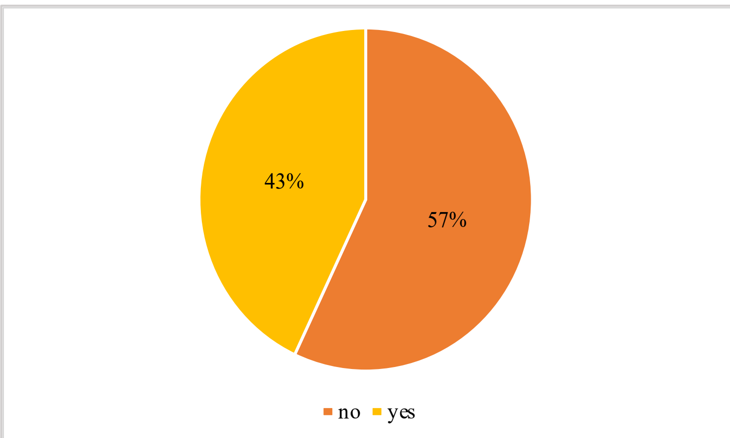

Figure 3-8: Have you ever heard about blockchain?

After this question, a definition of the blockchain technology (see paragraph 3.2.1 questionnaire design – section 6) was provided, and then were asked to the respondents what product they would value if blockchain was adopted. 45% of samples gave organic olive oil as answer, followed by 35% of PDO/GPI products, and 24% for both the mono variety and blend olive oil. For this question, 20% of the sample chose that they don't want to trace their products (Figure 3-9).

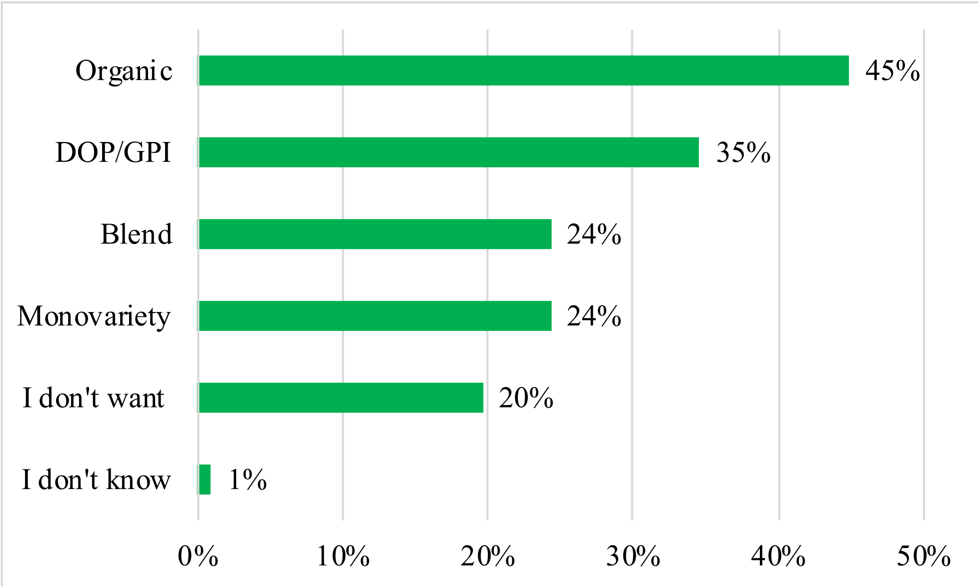

Figure 3-9: Which production do you want to valorize with the blockchain?

Then, the degree of agreement or disagreement to some sentences specifically related to the blockchain technology was asked. These were grouped considering the determinants previously explained (Table 3), and the average values were taken for each one. As it is shown by the figure 3-10, the highest averages are related to the trust on this technology, the effort expectancy, the performance expectancy, behavioral intention in adopting it, personal innovativeness and facilitating conditions, with all of them having an average around 3. For the other determinants, the averages are lower and closer to 2.5, especially the social influence and more than other the willingness to pay, showing 2.6 as average.

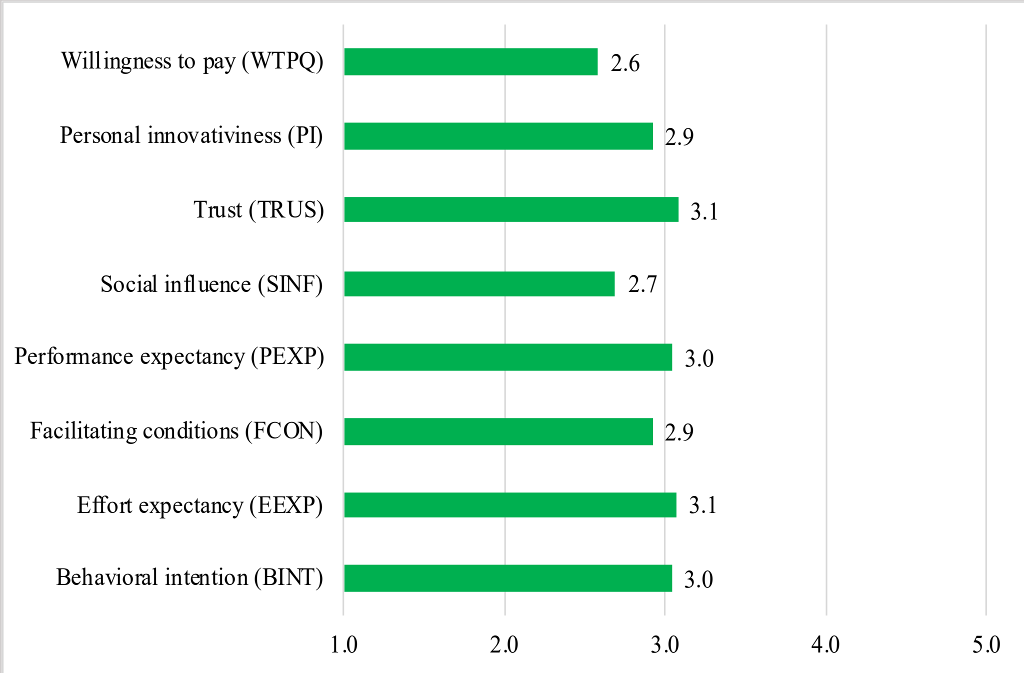

Figure 3-10: Determinant's average

3.3.4 Econometric model for producers' intention toward blockchain

The results of the investigation carried out have so far been presented only from a descriptive point of view. From now on the evaluation is going to be done from an econometric perspective. The validity of the latent constructs was analyzed through the evaluation of the Cronbach's alpha and the AVE, as shown in Table 6.

	EEXP	FCON	PEXP	SINF	TRUS	PI	BINT
Cronbach α	0.915	0.859	0.891	0.842	0.912	0.899	0.933
AVE	0.798	0.704	0.753	0.760	0.793	0.670	0.882

Table 6: Cronbach's alpha and AVE

Analyzing the values of both indicators we observe a high internal consistency between the measurements, therefore a high reliability of the scales. Once the validity of the latent constructs has been established, the predictive model for the behavioral intention was estimated. The results of the structural model are presented in Table 7.

Hypothesis	Variable	Coefficient	p-value	
H1	EEXP -> BINT	0.260	0.095	*
H2	FCON -> BINT	0.256	0.052	*
H3	PEXP -> BINT	0.034	0.788	
H4	SINF -> BINT	0.01	0.907	
H5	TRUS -> BINT	0.095	0.497	
H6	PI -> BINT	0.298	0.027	**
		r2	0.802	BINT
H7	BINT -> WTPQ	0.685	0.000	***
		r2	0.464	WTPQ
* *p < 0.10;* ** *p < 0.05;* *** *p < 0.01*				

Table 7: Results of the structural model

In our specific case, the model is used to analyze which, among the independent variables, shown previously, have a significant influence on producers' intention to adopt the blockchain technology (BINT). As can be seen from the table, there are three variables that have a significant influence on BINT (indicated with the * symbol) and these are: the effort expectancy (EEXP), the facilitating conditions (FCON), the personal innovativeness (PI) and each of them influence the intention to adopt the blockchain at different level. The coefficient values are all positive, meaning that the correlation between the two variables is always positive. Then the P-values are shown. These indicate the degree of the relations significance. The variable EEXP has a p-value of 0.095, lower than 0.10, so this has a positive influence, up to 90% on the BINT (the remaining % is given by other factors), indicating that hypothesis 1 is confirmed. This result is in line with what was found by Queiroz et al. (2020) and indicates that the degree of simplicity associated with using blockchain positively influences the intention to adopt the technology. This result is also in line with studies of Wong, Tan, et al. (2020) and Queirz & Fosso Wamba (2019).

Then the variable FCON also has a positive influence of 90%, in this case because the p-value is 0.052, always lower than 0.10. The significant and positive effect of this variable supports Hypothesis 2. The significance of this variable indicates that an individual's understanding of the resources, based on organizational and technical infrastructure, available in the firm to support the use of blockchain positively influences the use of blockchain technology. Furthermore, this result is in line with what emerged from Queiroz et al. 2020 and with the studies of Sanmukhiya (2020) and Wong, Tan, et al. (2020) which mutually figured out the positive effect of facilitating conditions on behavioral intention to use the blockchain.

The third variable which has a significant influence is the PI, in this case with a p-value of 0.027, lower than 0.05, meaning that the influence that it has on the BINT is higher than the one of the other variables and up to 95%. This indicates that hypothesis 6 is supported. This variable defines the disposition to adopt early novelties, including technologies like blockchain, for each single person. So, a result like this explains that among many possible factors capable of acting on the behavioral intention to adopt this technology, this one plays an important role. Those results agree with what emerged from other articles present in the literature, such as Boateng, et al. (2023), who studied how attitudes affect the blockchain adoption in an emerging market. The effective adoption is dependent not only on the capabilities of the technology itself, but also on the attitudes of people toward the technology. In this PI play an important role, of course together with other factors, giving several practical implications.

For the last variable BINT, in this case in correlation with the WTPQ, the willingness to pay, it has the lowest p-value in respect to the others, counting 0.000, which is lower than 0.01, giving an influence that it has is up to 99%. This variable has a high influence on the willingness to pay, supporting hypothesis 7, so those who are willing to adopt blockchain technology will also be willing to pay for this technology.

The fact that the variables PEXP, SINF and TRUST were not significant makes the hypotheses H3, H4 and H5 not supported. This indicates that Italian olive growers are not influenced by the performance expectations of the technology, they do not have social influences, and they are not influenced by trust towards other members of the supply chain. This could be linked to the fact that many of the interviewed do not know this technology.

The r^2 values shown in the table represent the goodness of fit's coefficient to understand how much that model is reliable. It indicates the proportion of total variance between two variables, which is explained by the model. For the fact that is a proportion, its value is always between 0 and 1 or between 0% and 100%. In general, higher is the r^2 value, so close to 1, higher is the predictive power of the model. As we can see from the table, the first r^2 value, related to the relationship between the variables with BINT, it' s up to 0.802 (80%) showing that the reliability is quite high. Anyway, the remaining percentage is done by other factors that play a role, and which were not taken into account in the analysis. For the second r^2 value, in this case related to the relationship between BINT and WTPQ, the value is lower and up to 0.464 (46%). In the field of study, especially the behavioral sciences, it is common to observe values lower than 50%. This doesn't mean that the model is not right, but the variable that we are analyzing doesn't depend just on the other one, but also on many other factors (Pozzolo, 2024).

These efforts could enhance perceived benefits and support acceptance among olive oil producers.

3.3.5 Willingness to pay for blockchain adoption

Lastly, in this paragraph the willingness to pay for the adoption of this technology is evaluated. The dichotomous choice revealed that when asked if he/she would be willing to pay 2000 €/year, only 11% of respondents answered yes, while the remaining 89% answered no. Among those who replied yes, nobody accepted the second offer of 3,000 €/year. Among those who answered no to the first offer, only 22% answered yes to the second offer of 1,000 €/year and most of the sample answered no.

From these results it is clear that only 33% would be willing to pay at least 1,000 €/year to use a blockchain service. For those who provided no to both proposals, the survey asked for what reasons the interviewed is not interested in paying the proposed service, asking to select 3 options.

As it is showed from the figure 3-11 the majority of the sample, up to 43%, answered that the main reason is that the blockchain is too expensive. The second reason gave was that they don't consider the company sufficiently digital, or the staff technically prepared in adopting it, in this case 30% of the sample. The third most chosen option was that they didn't understand what the blockchain is, together with the fact that they don't need an alternative traceability system for their products.

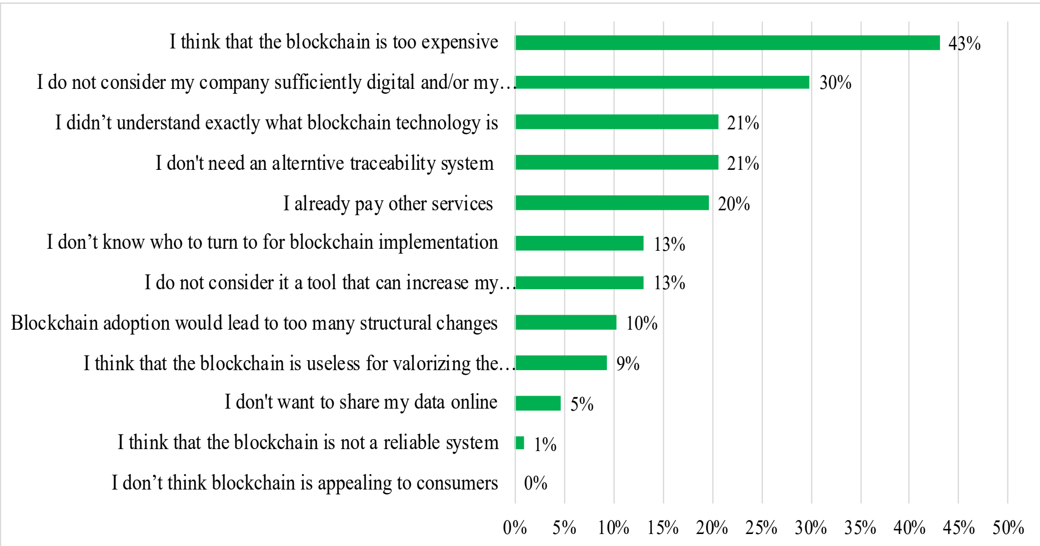

Figure 3-11: Main reasons for non-adopting the blockchain

CHAPTER 4
HYPOTHETICAL IMPLEMENTATION: BLOCKCHAIN SOLUTIONS FOR TRACEABILITY IN MARCHE'S OLIVE OIL SUPPLY CHAIN

To understand the possible efficacy of a blockchain system and its application in a company, for the valorization of its products, in the next paragraphs a real case is going to be presented and discussed. We will consider as case study an olive oil mill in the Marche Region who expressed the will to adopt a blockchain-based traceability system for a product of excellence: the monovarietal "Ascolana Tenera" Extra Virgin Olive Oil.

4.1 Company description

The company under analysis, which wants to apply this technology, is located in the Marche Region, specifically in the Fermo province, and was found in 1945. With 13 employees, the production is mainly focused on different types of extra virgin olive oil, such as the one made with the autochthonous olive variety in the area called "Ascolana Tenera". The mill also produces extra virgin olive oil under organic scheme and the PGI "Marche".

The production process in the company starts with the arrival of the olives, mainly from local producers, and the first step applied is the washing, together with the removal of leaves, branches and any foreign particles. Then, thanks to an automatized system that moves the olives, they pass through the grinder equipped with blades, and the olives are ground into paste. Then, the next step is the centrifugation in a machine which has 2 exists, one for the heavier watery part and the other one for the oil. So, the olive paste at the entrance is separated into two phases: oil and wet pomace, using the difference in density that the two components have. The water is expelled by the decanter coil together with the pomace, resulting in a wetter pomace. The pomace is stored outside the company and will be spread on the fields as a fertilizer, after a drying step to reduce its moisture content. The oil extracted is then filtered and it is moved to the storage tanks. The company stores the oil adding inside the tanks the nitrogen, a gas that substitutes the oxygen and allows a better conservation of the oil until its consumption, avoiding excessive oxidation. Once the product is ready, it is packaged using a machine which can put the oil in different types of bottles, applying the labels and finally the caps. The bottles are then organized manually by the employees in cardboard boxes of different size, and they are ready to be sold.

In the company, the possible application of the blockchain technology would be reserved for a specific EVO oil, which is the one made with the olive variety “Ascolana Tenera” as the company wants to valorize it through traceability.

4.2 Operational steps

According to the analysis of Chapter 4, we discovered that Italian olive oil producers are still reticent to adopt the blockchain in their companies, since they do not know the technology, nor they believe it will be too expensive. Considering their opinion, in this practical example the system proposed to the company for the traceability of its product is not the actual blockchain technology, but it is a system based on the blockchain functionalities. Thanks to the possibility of collecting information all along the supply chain, this system allows the consumer to "view" the production stages to which the product has been subjected and the raw material used. The traceability system is digital (based on the blockchain), which allows to record information in a permanent, immutable and transparent way. The blockchain will therefore act as a guarantor of the validity of the information provided by the actors in the supply chain. Rather than directly uploading data and information to the system, which is very expensive, a product image and a link to a data folder will be saved. The exploited system is InterPlanetary File System (IPFS). IPFS is a network protocol designed to create a decentralized and more efficient file storage and distribution system than traditional methods. Instead of relying on centralized servers to host and serve files, IPFS uses a peer-to-peer network. Each node in the network can store and share files, improving system resilience and reducing points of failure. If the file uploaded to this network is replicated across multiple nodes, even if one node becomes unreachable, the file is made available by others (Figure 4-1).

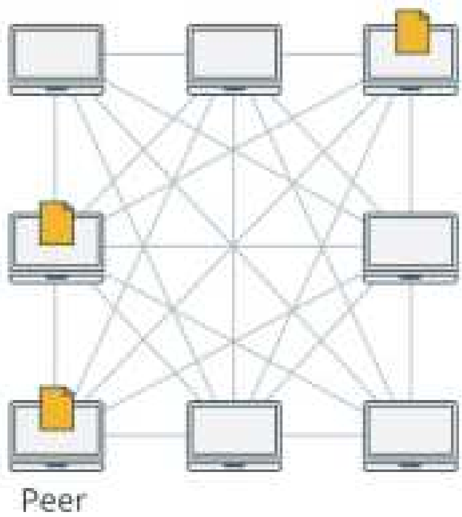

Figure 4-1: Peer-to-peer model IPFS

The generated link, once all the information the company intends to certify is uploaded, will act as a guarantor of the immutability of the information. If the data folder is changed (new information uploaded, existing information modified, information deleted), the associated link will automatically no longer work. The construction of this system is based on the following operational phases:

- Collection of field and mill data to reconstruct the supply chain stages. Each data must be accompanied by the date on which it was carried out and, where appropriate, a description of what has been done and/or relevant documents.
- The data collected are organized in a descriptive file that allows the end user to view the entire supply chain. The file should be in the pdf format.
- The data of supply chain and other documents made available by the manufacturer, such as photos, certifications, prizes are uploaded online in a folder (IPFS) that can be accessed through a third-party site (called Etherscan) through a transaction made by the producer.

Once uploaded, the file is no longer editable, ensuring the authenticity and integrity of the information. In fact, if the information is changed at any time, the link to the folder will no longer work and it will no longer be accessible. The third-party website displays, in addition to the link to the data folder, the name and image of the product tracked (which is called Non-Fungible Token - NFT). In addition, it is possible to see through a counter the number of people who have viewed the page and then consulted the information.

The third-party website is Etherscan, a blockchain explorer for Ethereum that allows users to view detailed information about transactions, address balances, smart contracts and other data related to the Ethereum network. It provides transparency and ease of access to data on the blockchain. In particular, with respect to NFTs, Etherscan facilitates access and verification of information on NFTs, increasing transparency and confidence in the ecosystem of unique digital assets on Ethereum.

To allow the consumer access to this online digital traceability system, it is necessary to label an indication such as "Certified supply chain traceability" and a reference to the product page on the company's website (for example, by QR code). In fact, the usability of the information is guaranteed by a link present within the specific product page on the manufacturer's website: through a "Verify the traceability of the supply chain", in fact, the consumer will finally be referred to the third-party site containing all information above. Figure 4-2 shows how the website interface will present the link to Etherscan.

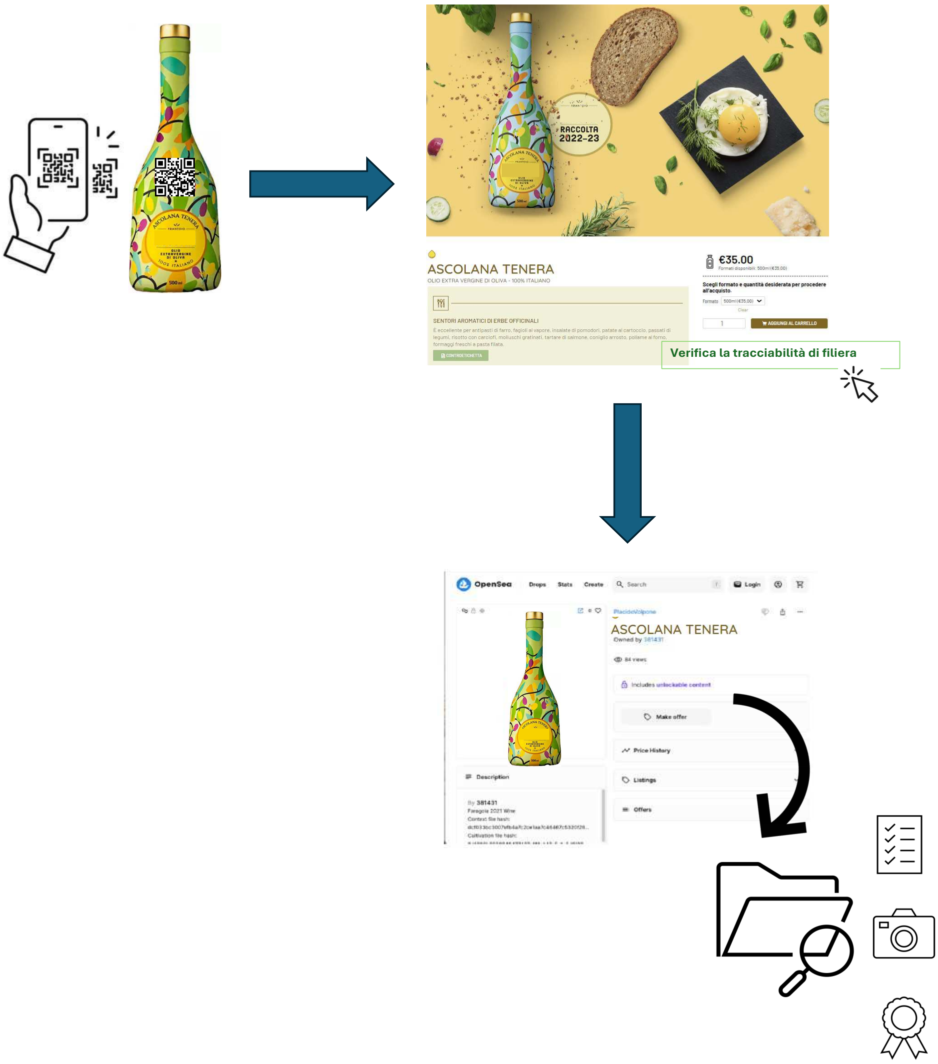

Figure 4-2: Company's website interface to allow consumers to access the IPFS blockchain. The interface is in Italian.

Thanks to this system, based on the blockchain technology, there are positive insights for both the consumer and the producer. The consumer, buying this product, is going to be able to trace all the supply chain, starting from the raw materials, and being sure that the olive variety used is the actual "Ascolana Tenera" that come from that specific area of origin and the production process is applied as indicated on the label, respecting the parameters specified. On the other hand, from the producer's point of view, this system allows to valorize a production, ensuring its quality, authenticity and security, differentiating it from the competitor's products. This can increase the company's competitiveness on the market. In addition, the system would in turn reinforce the consumer trust, reducing the risk of food frauds at which the olive oil is often exposed, promoting the purchase of products with quality marks.

CONCLUSIONS

The olive oil sector is one of the most important components of the agri-food in Europe, and even more in Italy, but at the same time has also many weaknesses, being very often subjected to actions that aim to fraud consumers. Italy has a very important role in this sector, being the first consumer and importer of olive oil and the second producer and exporter, with the first position occupied by Spain, which has the highest number of hectares of olive trees in Europe. In Italy the sector is driven by the extra virgin olive oil and its production, most of all done in Puglia, together with the other regions in the south, where there is also the highest number of active mills. This of course for the fact that the climate in the South is the most appropriate for the cultivation of the olive trees. An important push in this sector is done by the IG oils, products that have the power to valorize a specific area with its productions, but it is right here that the weaknesses arise. These types of products, having quality certifications like PDO or GPI, and being sold at higher prices, attract phenomena that aim to simulate their quality, but actually giving products with a very low standard.

At this point the blockchain has a promising role. Born for the bitcoin sector, with its characteristics, it allows to make the data it collects essentially immutable, stopping the possibility for external people outside the operators of the distributed platform, to act and manipulate such data. This technology has the potential to be applied in the agri-food sector, because for its features, can be used to track all the supply chain. This in turn is a tool for the consumer, who has the opportunity to certify that the information provided for the products are real, but even for the producer, main objective of this thesis. Producers, using this technology, can valorize their productions and differentiate themselves for the other competitors in the same sector.

The main objective of this thesis was to understand the intention to adopt the blockchain technology by producers that work in the olive oil sector, as a tool for traceability of their products. From the analysis applied, thanks to a survey spread between producers, it came out that just a part of the sample, the 43%, already knows the blockchain, and inside this value there were different reasons gave for the insecurities that the producers have in adopting it. The first reason that came out, is that the blockchain system is too expensive. This followed by a part of the sample that said that they don't feel themselves ready to adopt and use this technology, or because they think that their company is not ready for it. The third reason given, is that the don't really understand what the blockchain is and its possible application in their company. In fact, applying the econometric model for the statistical analysis, it came out that between the variables considered, the ones that have an influence on the adoption of the blockchain are the effort expectancy, the facilitating conditions, but especially the personal innovativeness, which influences more than the others the intention to adopt this technology and then the willingness to pay for it. From this study it seems that variables like the trust on this technology don't have an influence in the final adoption of the service, or at least not too much, meaning that most of the sample considers this technology safe. This result is also confirmed by other articles available in the literature.

So, it is clear that if the goal is to spread the use of this technology in many different sectors, including the agri-food, as the European guidelines and even the Italian law suggests, it is necessary to work on spreading information about this technology and its possible applications, to make more aware people of its possible benefits, not just for the consumer but also for producers' point of view. Before using this technology, it is necessary that people, and in details producers, are prepared and able to use it with all of its functionalities.

Positive attitudes toward blockchain may be influenced and, at the same time, adoption rates can increase by disseminating easy-to-understand information about its benefits and ease of usage. By making blockchain more accessible and user-friendly, organizations can encourage companies with varying technological backgrounds to adopt this technology. By addressing the knowledge gap and providing ongoing assistance, organizations can facilitate the adoption process, reducing potential concerns or hesitations. By fostering positive attitudes, encouraging personal innovativeness, and addressing usability concerns, the successful implementation and adoption of blockchain can be facilitated, leading to its broader societal and economic impact.

Important is to clarify that the sample of the producers analyzed is not so wide, it is just related to Italian producers and related to a specific product, which is the extra virgin olive oil. Saying this, it is important to specify that we can't generalize what it was explained before. In fact, the analysis conducted represents a starting point for understanding the possible applications of this technology. This will be followed by further and more in-depth studies to obtain a more precise picture of the blockchain, highlighting in detail its possible applications in the agri-food sector, as a tool for ensure the traceability of foodstuffs.

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"Live right now
Yeah, just be yourself
It doesn't matter if it's good enough
For someone else"

ANNEX 1

Questionario di indagine alle aziende produttrici di olio extravergine di oliva (EVO) riguardo l'intenzione a adottare la tecnologia blockchain

Il presente questionario è parte integrante del progetto nazionale di ricerca PRIN 2020 "W.E.B.E.S.T.", dell'Università Politecnica delle Marche - Agraria, ed è svolto in collaborazione con l'Organizzazione dei Produttori Olivicoli APROL Marche - Società Coop. Agricola e UNAPROL - Consorzio Olivicolo Italiano. Tale progetto si propone di valutare l'applicabilità della tracciabilità digitale per valorizzare le produzioni *Made in Italy*.
La presente indagine ha come obiettivo quello di valutare la propensione delle aziende della filiera dell'olio extravergine di oliva (EVO) ad adottare la tracciabilità digitale, nell'ottica di aumentare la propria competitività sul mercato nazionale ed estero. Lo studio risulta estremamente rilevante anche alla luce della nuova Legge 206/2023 (entrata in vigore l'11 gennaio 2024) che ha l'obiettivo di rafforzare le filiere strategiche *Made in Italy,* attraverso l'utilizzo della tecnologia digitale, definita blockchain, per la valorizzazione dell'olio EVO.

Le sottolineiamo che il suo nome non verrà in alcun modo divulgato, che esso verrà archiviato in forma separata dalle sue risposte, e che i dati raccolti in tutto il campione saranno elaborati in forma aggregata nel rispetto della legge sulla privacy. *

*SEGRETEZZA DEI DATI FORNITI CON IL PRESENTE QUESTIONARIO
Ai sensi del Regolamento (UE) 2016/679, GDPR (*General Data Protection Regulation*), e del Decreto legislativo 196/2003, e successive modifiche ed integrazioni, tutte le informazioni raccolte con i questionari saranno utilizzate esclusivamente per scopi di ricerca scientifica. I dati raccolti nell'ambito della presente indagine, inoltre, sono tutelati dal segreto statistico e pertanto non possono essere comunicati o esternati se non in forma aggregata, in modo che non se ne possa fare alcun riferimento individuale, e possono essere utilizzati solo per scopi statistici.

Compilando il questionario, acconsente a partecipare a questo studio.

- o Acconsento
- o Non acconsento

Ordinamento tecnico economico dell'azienda intervistata

1. *Che tipo di attività svolge l'azienda?*
- o L'azienda produce e molisce olive in frantoio di proprietà
- o L'azienda produce olive ma le molisce in un frantoio contoterzi
- o L'azienda molisce le olive ma non le produce (frantoio)
- o L'azienda produce olive
- o Confezionatore

2. *La sua azienda si occupa direttamente della commercializzazione dell'olio di oliva?*
   - o Sì
   - o No

Livello di digitalizzazione dell'azienda

3. *Indicare, su una scala da 1 a 5 il grado di accordo/disaccordo con le seguenti affermazioni (dove: 1 Completamente in disaccordo; 2 In disaccordo; 3 Indeciso; 4 D'accordo; 5 Completamente d'accordo)*

	1	2	3	4	5
Non sono una persona tecnologica	o	o	o	o	o
Sono riluttante ad apprendere nuove tecnologie	o	o	o	o	o
Mi sento a disagio quando uso la tecnologia	o	o	o	o	o
La tecnologia non migliora la qualità della mia vita	o	o	o	o	o
Sento di non aver il controllo della situazione quando uso la tecnologia	o	o	o	o	o
Usare la tecnologia mi preoccupa	o	o	o	o	o
Mi sembra che la tecnologia possa complicare dei compiti semplici	o	o	o	o	o
È impossibile tenere il passo con le nuove tecnologie	o	o	o	o	o
Mi sento inefficiente quando uso la tecnologia	o	o	o	o	o
Utilizzare la tecnologia mi rende nervoso/a	o	o	o	o	o
A volte, utilizzare la tecnologia mi infastidisce	o	o	o	o	o

4. *Nel contesto olivicolo italiano, quanto considera la sua azienda tecnologica o digitale? Esempio: l'azienda è poco digitale se utilizza solo e-mail e Whatsapp; l'azienda è eccellente se applica anche agricoltura di precisione in campo, o soluzioni industria 4.0.*

	1	2	3	4	5	
Molto poco	o	o	o	o	o	Eccellente

5. *Negli ultimi anni si stanno sviluppando nuove tecnologie digitali per garantire l'origine e la tracciabilità dei prodotti. In particolare, si parla di blockchain per la valorizzazione dell'olio di oliva. Ha mai sentito parlare di questa tecnologia?*
- o Sì
- o No

Definizione di blockchain
Per blockchain si intende un servizio informatico/digitale che permette all'azienda di poter registrare il percorso dei propri prodotti (anche solo uno) dal campo alla tavola, lungo tutta la filiera. Questo permette di tracciare l'intero percorso dell'olio, garantendo la trasparenza, l'integrità dei dati e la conferma della sua identità. Una volta che i dati relativi al prodotto sono stati registrati, il sistema può creare un'etichetta digitale (QR code) con la quale il consumatore può tracciare il prodotto e visualizzare il racconto della filiera. È un sistema che tutela sia il produttore che il consumatore.

Volontà di adottare la blockchain

6- *Indicare, su una scala da 1 a 5 il suo grado di accordo/disaccordo con le seguenti affermazioni (dove: 1 Completamente in disaccordo; 2 In disaccordo; 3 Indeciso; 4 D'accordo; 5 Completamente d'accordo).*

	1	2	3	4	5
Ho intenzione di adottare la blockchain in futuro	o	o	o	o	o
Prevedo di adottare la blockchain in futuro	o	o	o	o	o
Sto pianificando di adottare la blockchain in futuro	o	o	o	o	o
Penso che possa essere facile per me imparare ad utilizzare la blockchain	o	o	o	o	o
Penso che la mia esperienza con la blockchain potrà essere agevole	o	o	o	o	o
Penso che la blockchain possa essere facile da utilizzare	o	o	o	o	o
Penso di poter facilmente diventare abile nell'utilizzare la blockchain	o	o	o	o	o
La mia azienda ha le risorse tecnico-economiche necessarie per adottare la blockchain	o	o	o	o	o
Ho le conoscenze necessarie per adottare la blockchain	o	o	o	o	o
La blockchain è compatibile con altre tecnologie che utilizzo	o	o	o	o	o
Se dovessi riscontrare difficoltà nell'utilizzare blockchain, saprei di poter contare sul supporto di qualcun altro	o	o	o	o	o
Penso che la blockchain possa essere utile nella vita di tutti i giorni	o	o	o	o	o
Credo che l'adozione della blockchain possa aumentare le possibilità di raggiungere traguardi importanti	o	o	o	o	o
Penso che l'utilizzo della blockchain mi possa aiutare a completare le mie mansioni più velocemente	o	o	o	o	o
Utilizzare la blockchain potrebbe aumentare la mia produttività	o	o	o	o	o
Le persone a me vicine credono che dovrei utilizzare la blockchain	o	o	o	o	o
Le persone che influenzano il mio comportamento pensano che dovrei utilizzare la blockchain	o	o	o	o	o
Le persone di cui rispetto l'opinione preferiscono che io usi la blockchain	o	o	o	o	o
Credo che la blockchain sia affidabile	o	o	o	o	o

Mi fido della blockchain	o o o o o
Non nutro alcun dubbio sull'affidabilità della blockchain	o o o o o
Sono convinto/a che gli apparati legali e i sistemi tecnologici mi possano proteggere adeguatamente dai problemi legati alla blockchain	o o o o o
Credo che la blockchain possa raggiungere l'obiettivo per cui la applico	o o o o o
Credo di conoscere di più la tecnologia blockchain rispetto ad altri	o o o o o
Se ne avessi già sentito parlare, avrei già cercato di adottare la blockchain	o o o o o
Tra i miei colleghi, sarei il primo/a a provare la blockchain	o o o o o
Mi piace sperimentare le nuove tecnologie come la blockchain	o o o o o
Penso di utilizzare la blockchain anche se non conosco nessuno che già ne faccia uso	o o o o o
Userò la blockchain anche se il prezzo per adottarla è alto	o o o o o
Sono disposto a pagare un prezzo più alto per utilizzare la blockchain rispetto ad altre tecnologie simili	o o o o o
Se dovessi adottarla, sarei intenzionato/a a continuare ad utilizzare la blockchain anche se il prezzo dovesse aumentare nel tempo	o o o o o

Disponibilità a pagare per la blockchain

Per tracciare uno o più prodotti aziendali attraverso blockchain è possibile acquisire **un servizio in abbonamento annuale**. Il servizio offerto prevede:

- La registrazione in blockchain dei dati relativi alle varie fasi della filiera
- La convalida digitale dei dati
- La condivisione dei dati sia con gli interlocutori commerciali che con il consumatore finale attraverso etichette digitali
- Creazione di una pagina web dedicata per la consultazione dei dati di filiera
- La tutela della sicurezza informatica dei dati caricati online
- Assistenza e manutenzione di un addetto di un'azienda terza

Il costo del servizio annuale è forfettario e, quindi, indipendente dal quantitativo finale di prodotto commercializzato.

6. *Sarebbe disposto/a a pagare **2000 €/ANNO** per il servizio in abbonamento annuale blockchain proposto?*
   - o Sì (vai alla domanda 8)
   - o No (vai alla domanda 9)

7. *Se sì, sarebbe disposto/a a pagare **3000 €/ANNO** per il servizio in abbonamento annuale blockchain proposto?*
   - o Sì
   - o No

8. *Se no, sarebbe disposto/a a pagare* ***1000 €/ANNO*** *per il servizio in abbonamento annuale blockchain proposto?*
   - o Sì
   - o No (vai alla domanda 10)

9. *Per quali ragioni non è interessato/a ad accedere al servizio blockchain proposto? (si prega di selezionare 3 opzioni)*

☐ Non ho bisogno di un servizio di tracciabilità alternativo
☐ Immagino che la blockchain sia troppo costosa
☐ Penso che la blockchain non sia un sistema affidabile
☐ Pago già altri servizi e non voglio pagare altre cose aggiuntive
☐ Non mi va di condividere i miei dati on-line
☐ Penso che la blockchain non sia utile per valorizzare la qualità del mio prodotto
☐ Non credo che la blockchain sia accattivante per i consumatori
☐ L'adozione della blockchain comporterebbe troppi cambiamenti a livello strutturale
☐ Non lo ritengo uno strumento che può aumentare la mia competitività sul mercato
☐ Non saprei a chi rivolgermi per implementare la blockchain
☐ Non reputo la mia azienda sufficientemente digitale e/o il mio personale tecnicamente preparato
☐ Non ho capito esattamente cos'è la tecnologia blockchain

Informazioni generali sull'azienda

10. *Regione/Provincia*

____

11. *Tipologia di produzione*

o Convenzionale
o Biologica
o Integrata

12. *Che tipo di produzione ha?*

☐ IGP/DOP
☐ Biologico
☐ Monovariatale
☐ Blend
☐ Altro (specificare) __________________

13. *Quali produzioni vorrebbe valorizzare con la tracciabilità digitale blockchain?*

☐ Non voglio tracciare i miei prodotti in blockchain
☐ IGP/DOP
☐ Biologico
☐ Monovariatale

☐ Blend
☐ Altro (specificare) _________________

14. *Superficie olivetata (ha) (se solo frantoio o confezionatore indicare 0)*
____

15. Tipologia di impianto dell'oliveto
- o Tradizionale
- o Media densità
- o Intensivo
- o Super-intensivo
- o Non possiedo oliveto

16. Tipologia di impianto del frantoio
- o Impianto a 2 fasi
- o Impianto a 3 fasi
- o Non possiedo frantoio

17. Tipologia di estrazione del frantoio
- o Impianto convenzionale
- o Impianto a freddo
- o Altre tecnologie per preservare la qualità
- o Non possiedo frantoio

18. Quanti litri di olio confeziona all'anno? (indicare 0 se non confeziona olio)
____

19. Con quante referenze/varianti di prodotto si posiziona sul mercato?
____

20. Categoria in cui rientra l'azienda di cui è proprietario/dipendente:
☐ Microimpresa
☐ Piccola-Media impresa
☐ Grande impresa

21. Percentuale di vendita nel mercato regionale (si prega di indicare un numero da 0 a 100):
____

22. Percentuale di vendita nel mercato nazionale (si prega di indicare un numero da 0 a 100):
____

23. Percentuale di vendita nel mercato estero (si prega di indicare un numero da 0 a 100):
____

24. *Se esporta l'olio, potrebbe indicare i principali Paesi destinatari? (se non esporta all'estero, indicare* ***Nessuno****)*

____

25. *Principali canali di vendita dell'olio*

- ☐ Vendita diretta
- ☐ GDO
- ☐ E-commerce
- ☐ Ho.Re.Ca.
- ☐ Intermediari
- ☐ Altro (specificare)

____

Informazioni sull'intervistato

26. *Genere*

- o Maschio
- o Femmina

27. *Età*

____

28. *Titolo di studio*

- o Elementari/medie
- o Scuole superiori
- o Laurea
- o Post-Laurea (master/dottorato di ricerca)