

The BC for the sustainability of Designations of Origin and the Quality Agri-food Districts: The case of Vermentino di Gallura D.O.C.G.

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Abstract. The study describes the implementation hypothesis of the BC (BC) Technology within a specific wine-growing area, production area of a unique Controlled and Guaranteed Denomination of Origin at an international level, that of Vermentino di Gallura DOCG, located in the Region Sardinia (Italy). The paper is structured as follows: first, the operating scheme of the BC technology is briefly summarized and the type of plant to be used is identified for the purpose of this study, that of protecting the DO, transparency and simplification of practices of certification. The main uses that BC has had in the agri-food sector in general are recalled below, with a focus on the wine sector. The two paragraphs constitute an indispensable premise for the introduction of our BC implementation hypothesis in the specific case study. In fact, the second part of the work is dedicated to the description of the Vermentino di Gallura DOCG production system, and of some critical issues that could be overcome with the implementation of the BC Technology. The innovative aspect within the existing literature is represented by the fact that in this case it is not a question of applying BC's writing to a single company (mono-objective), but to the protection of a designation of origin and the guarantee of compliance with a Production Disciplinary, still little studied in the wine sector. Based on the variety of process types that populate the Agro-food Quality District, different writing options and different BC certification hypotheses will be presented. This is a first approach that we intend to implement and specifically study directly within a future research project.

1 Introduction

The growth of ICTs over the last decade has provided many opportunities to overcome some of the challenges faced in agriculture. Recent developments such as the increase in the use of mobile broadband access devices, Internet of Things (IoT), drones, smart grids, Big Data analytics capabilities and Artificial Intelligence, have provided different agricultural players with some tools and key technologies to improve both production processes and marketing actions, in the strictly agricultural sector but also in related and/or connected upstream and downstream sectors [1].

The fundamental theme in the case of DOs is that of protection from counterfeiting and traceability and transparency in favor of the consumer. Numerous initiatives are being tested in agricultural value chains aimed at tracing products on the basis of Geographical Indicators (GI), favoring and encouraging good practices and penalizing unsustainable illegal enterprises. Greater transparency in the process and supply chain path, also through the creation of a BC (BC), makes it possible to

build an immutable product certification from the field to the table to protect production on the one hand, and the consumer on the other, reducing the information asymmetry, increasing the reputation of the brand, the DO and/or the Agro-food Quality District (DAQ).

Studies dealing with the application of the Block Chain (BC) technology to the agri-food sector, with drivers and barriers, as well as with benefits and challenges of the BC have increased in the recent literature as revealed by reviews published as early as 2023 [one for all 2].

When integrated with the latest IoT technologies for data acquisition, it has enormous potential in the agri-food sector: while on the one hand IoT solutions connect the physical and digital world by acquiring data such as T and Humidity during transport or storage of product, on the other the BC provides a secure and immutable platform in which this data can be sent and made accessible to every actor in the supply chain. A recent report (Key vertical opportunities, trends and challenges

2020-2030), by the American company Juniper Research highlights that BC integrated with IoT sensors and trackers will be increasingly used in the agri-food sector because it offers various advantages including: a simplification of the supply chain and a reduction in costs for retailers; streamlined regulatory compliance; an improvement in the timing associated with the food withdrawal process; a considerable saving in terms of global food fraud, a reduction in transaction costs, an increase in efficiency; the guarantee of the transfer of part of the profits to the farmer/producer. They estimate that \$31 billion in business could be achieved by 2024. The FAO policy paper (2019) points out that BC technologies will help build an “immutable contract” between various supply chain players. This work explores the theme of digitization in the wine sector, with specific reference to BC technology, with the specific aim of highlighting the resulting advantages in order to guarantee sustainability and protection of the Designations of Origin and of the Agro-Food Districts of Quality (DAQ). It is a food and wine heritage that in Italy assumes extremely important numbers: in 2020 the PDO economy represented, in fact, 19% of the total turnover of the Italian agri-food sector, thanks to the contribution of the major certifications (ISMEA-Qualivita, 2021) distributed on the whole national territory. In the same way, the legislation concerning the DAQ (National Legislative Decree 228/2001) has made it possible to identify production areas characterized by a significant economic presence and by the productive interrelation and interdependence of agricultural and agro-food companies as well as by one or more certified and protected products, such as local governance model aimed at guaranteeing a balanced growth of local systems.

The study presents the hypothesis of implementation of the BC technology within a specific wine-growing territory, production area of a Controlled and Guaranteed Denomination of Origin known internationally, that of Vermentino di Gallura DOP, the only denomination of the Sardinia Region (Italy). The paper is structured as follows: first, the operating scheme of the BC technology is briefly summarized and the type of plant to be used for the purpose of this study is identified; the main uses that BC has had in the agri-food sector in general are recalled below, with a focus on the wine sector. The two paragraphs constitute an indispensable premise for the introduction of our BC implementation hypothesis in the specific case study. In fact, the second part of the work is dedicated to the description of the Vermentino di Gallura DOP production system, and of some critical issues that could be overcome with the implementation of the BC technology. Furthermore, the process of setting up the DAQ of Vermentino di Gallura is briefly summarized. The innovative aspect compared to the existing literature is represented by the fact that in this case it is not a question of applying BC to a single company (single-objective), but to the protection of a designation of origin, as a guarantee of a production process that is made within a specific production area which is also subject to compliance with a well-detailed Production Regulation. Based on the variety of process types that populate the Vermentino di Gallura DOP quality agro-food district,

different writing options and different BC certification hypotheses will be presented. Therefore the application of the BC is multi-objective and is reasoned on several levels of certification: those relating to the production of wine, and those subsequent to the corporate gate, going to affect the main players involved in the transport, storage and sale of the wine itself (at local, regional, national and international). Some final considerations follow.

1.1 BC systems

The principles on which BS technology is based are related to transparency, open source, autonomy, immutability and anonymity [3], although the concrete implementation of the system may not guarantee that all above principles are met and some problems should be considered, as those regarding the governance of the blockchain [4].

As an evolution of the first type of BC that was a permissionless open blockchain, two other main types of blockchains have been developed: opposite to the public permissionless BC, the private permissioned type; and the so-called consortium blockchain [5] as a type that stays in the middle. The three types mainly differ for the consensus rule, the transparency level and the immutability [3]. In a consortium blockchain a distributed consensus is reached by a set of predetermined users (nodes) that have an access right linked to their identity, with a collaborative authority that acts as validator with consensus power [6]. It has several characteristics compared to the other BC types: it is more decentralized compared to the permissionless type, less decentralized than private type, in that a small group of nodes is responsible for the validation of the block; in addition, consortium BC have a higher adaptability, exchange speed and security compared to the permissionless type, while its digital security is higher than that in a private BC system [7]; finally, information is better leveraged than the private type to improve transparency and accountability [8] and is quite flexible and appropriate for applications where entities do not often change [9].

1.2 BC for the wine supply chain

The wine industry is among the most studied sector in literature concerning the application of BC and other digital tools to the agri-food [10].

The reasons for this attention can be partly related to internal characteristics and needs of the sector, partly to the opportunities that BC offers to meet these needs.

As regards the internal characteristics of the wine industry which motivate the sensitiveness of actors along the supply chain towards the BC, a high competitiveness of the sector is often underlined as a factor that induces both the search for sources of competitive advantages and the need for product/brand positioning in the top market segments. Other motivations in the sphere of competitiveness were referred to the wine industry openness to international markets and to the innovative atmosphere and the firms' attitude; in addition, the costs of product counterfeiting and safety risks in terms of

firms' efficiency and profitability and in terms of brand image were reasons for searching preventive solutions in order to reduce the impacts of real cases experienced in the wine industry. Furthermore, regarding certified wines the relation between the product and the territory is another characteristic that create opportunities as well as risks within actors in local supply chains.

Related to the above characteristics, are the opportunities offered by BC technology. At this regard, the literature points to opportunities and benefits offered by BC technology staying mainly in the spheres of transparency, traceability [11,12], counterfeiting and trust [6,13-15].

Recent studies [16] tried to enlarge the opportunities offered by BCs in terms of the environmental and social sustainability performances of wine industries or supply chains for satisfying consumers' sensitiveness.

Some literature dealt with the obstacles the BC implementation may pose and the resources –financial, human, and organizational among others- needed both within hypothetical contexts or based on real cases [14,17]; finally, some studies elucidated on the value added of BC compared with other virtual systems, as well as on their integration [18].

A platform specifically designed for wine producers is MyStoryTM, a solution developed by VeChain -a BC service provider- for the DNV GL group that includes in its system a blockchain structure and other IoT smart devices. MyStory is an open permissioned BC that offers the wine producers the opportunity to share with consumers –through a QR code- the authentic product story, from quality to social, environmental or ethical integrity of a product, displaying facts verified by DNV GL that are stored on a blockchain platform [19]. Another BC system, Wine Blockchain, was developed by the Ernst and Young (EY) in collaboration with EZ lab a start-up technology developer. As far as Italy, eNology, a public blockchain platform project and a webApp, were designed for wine-production-chain certification. It was supported by the Italian Ministry of Agriculture and Forestry (MIPAAFT), in collaboration with Almagiva (a developer), SIAN (National Agricultural Information System) and AGEA (Agricultural Supplies Agency) in order to integrate data available from different institutions (the firms' register, the vineyard register of the winery, the annual grape harvest declaration, the dematerialized register of cellar operations) in a BC project aimed at increasing traceability, combating counterfeiting and enhancing Made in Italy wine towards the final consumer.

Almost all studies applied a case study approach that is motivated by the novelty of the phenomenon and sometimes applied by linking real-life experiences to some theoretical backgrounds developed within different disciplines. Furthermore, the studies very often report surveys aimed at gathering the opinions of actors along the supply chains and of experts. Surveys were oriented towards studying the readiness in the introduction of BC technologies, the diffusion of existing BC applications among the actors of the wine supply chain [20], as well as towards the investigation of potential or concrete benefits

and obstacles [17], when BC were only envisaged or already applied in real cases.

Most cases and literature regarded single firms, mainly medium sized than SMEs [19,21], integrated process from vineyards to wine, or simplified supply chains; few studies enlarge the perspective of BC adoption to wine consortia, as in the case of a hypothetical implementation to the ETNA doc wine in [20] or complex supply chains that often characterised wine production. Indeed, it is quite common to find complex wine supply chain including at least the following components before the consumers' purchase: grape grower, wine producer, bulk distributor/transit cellar, filler/packer, finished wine distributor, wholesaler, retailer, and other actors when the product is internationally traded, can feed the wine chain. The raw material and product are transferred and involve actors along the chain that sign a digital contract that should be authenticated in order to fix the exchange; in this way a flux of information adds to the flux of goods exchanged along the chain.

Finally, studies had mainly a descriptive approach and general content that make difficult the replicability of BC design, structure and procedures to other wine industry and supply chains. With [13] words "the literature still lacks a clear operationalization of the BC system construct, as well as a complete overview of all the relevant variables that can be used to design a BC system".

Probably due to a BC early adoption and in a few case studies, there is no widespread assessment of the impacts of the technology on companies (in terms of business models, effectiveness and efficiency of inter-organizational business processes, and of firms' performance) and on consumers, but some studies have tried to extrapolate impacts based on qualitative approaches [6,3].

Although the BC case studies are differently settled, information regarding the supply chain could be listed as follows: grape used, the area of origin and the cultivation process (e.g. vineyards location, age, surface and yield, climate, water and soil parameters, pesticides and fertilizers application); wine farmers, cooperatives, integrated wineries and the transformation processes (e.g. type of vinery, n. of bottles produced, varietal composition, chemical and organoleptic characteristic of a bottle); storage companies and market intermediaries (e.g. type of tanks, contents, date of storage/transportation, distance of transportation), as well as a series of contents (e.g. certifications and eco-labels), multimedia (e.g. videos, storytelling) and other information (recipes, initiatives, fairs and tastings, wine tourism events, etc ...) related to a bottle of wine.

2 The constituting Agro-Food Quality District of Vermentino di Gallura DOCG

Before proceeding to represent the functions that BC technology is called upon to perform in the analyzed case study, it is appropriate to describe the recognition process

of the Vermentino di Gallura Quality Agro-food District and its hypothesized network of relationships which must be protected and guaranteed, as a fundamental purpose. However, as will be seen later, the reasons for writing and certifying in BC will be specified from time to time as the various process certification simulations are presented.

2.1 History and structure of the constituting Quality Agro-Food District of Vermentino di Gallura D.O.C.G

2.1.1 The guidelines and purpose of its establishment

The reference legislation is represented by the Regional Law n. 16 of 2014 “Regulations on agriculture and rural development: agro biodiversity, collective branding, districts” and the related implementation directives attached to the Regional Council Resolution n. 11/8 of 11.3.2020.

The districts have the objective of promoting the development of the territories and their production systems, with an above all planning function and connection between companies, public bodies and civil society. They are non-profit entities and of collective interest.

The promoter is required to implement territorial animation actions to ensure the widest consultation involving the economic, social and institutional representatives of the territory. The action of animation must be carried out through no less than six public sharing meetings.

The Consortium for the Protection of Vermentino di Gallura D.O.C.G is the lead partner, promoter of the establishment of the DAQ with a conspicuous representation of its wine producers, but also together with other local institutions such as Confagricoltura, Confartigianato, the Chamber of Commerce of Sassari, the Association of Italian Sommelier section of Sassari, the Berchidda Wine Museum, Badesi transport company, two nautical clubs, the Karasardegna company that promotes local food and wine products in Sardinian airports, and some municipalities (Olbia, Badesi, Loiri Porto San Paolo). The animation process involved a cycle of seven meetings that took place between October 2022 and February 2023.

The key values that guided the participatory process for the establishment of the DAQ of Vermentino di Gallura D.O.C.G can be summarized as follows:

- Openness and Participation with an approach, oriented towards inclusion and listening to different needs and points of view, which has been structured in a Participatory Planning process with the use of tested methodologies and widely adopted by Laore technicians;
- Representation, guaranteeing the widest consultation involving the economic, social and institutional representatives of the territory;
- Inclusivity with the widest possible involvement of the actors, which has allowed the creation of

participatory meetings as opportunities for discussion, listening and learning;

- Transparency, information and communication to maximize the promotion of events and the dissemination of results achieved during work meetings;
- Co-planning and result orientation: the extreme concreteness of the outputs of each multi-stakeholder territorial animation meeting contributed to the elaboration of contents that fed the various sections of the programmatic plan.

The impetus for the creation of the Quality Agro-Food District of Vermentino di Gallura D.O.C.G. stems from the belief that the creation and/or strengthening of relationship networks between local actors, which in various ways revolve around the production of wine, can act as an activator of local development, as widely recognized by the scientific literature which sees in the creation of social capital the founding element of the development and growth of an economy. In fact, the competition between territories is played out not only on the endowment and organization of market resources (tax regimes, labor costs, market incentives) but also on resources and extra-mercantile social ones (endowment and density of a relational fabric inside and outside the companies).

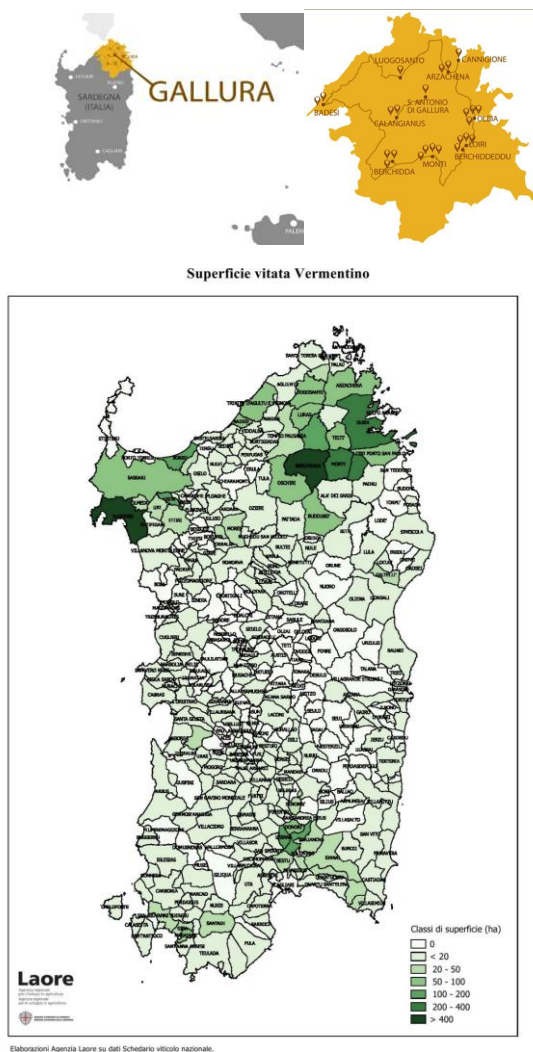
The main competitive advantages deriving from the establishment of the DAQ are many, both at a strictly company level (for the wineries involved in the production of Vermentino) and at a local level (in the Gallura area) and as a whole (also affecting companies of other sectors of the local economy connected upstream (for example the cork industry) and downstream (for example the restaurant industry) with the same wineries. They can be briefly summarized as follows:

- Enhancement of the wine sector through the link with the territory on the one hand, and through the increase of sustainability (economic, environmental and social) on the other;
- Support for the internationalization of wine through targeted and participatory promotion actions;
- Introduction of process and product innovations through Research and Development in collaboration with research institutions and universities;
- Participation in tenders for research/innovation projects and other promotional initiatives, financed with regional, national and/or community, public or private resources, both individually and in association with other companies, institutions, universities, research centres.

2.1.2 Geographical representation and network of stakeholders involved in the animation process and future DAQ actors

As can be seen from the map of the distribution of the vineyard area in 2020 (Laore), Gallura represents one of the wine-growing areas of the region with the highest concentration of vineyard areas: here are located 9% of the regional vineyard area and 31% of the vineyard area

of the province of Sassari; the municipalities of Berchidda and Monti alone group 14% of the vineyard area in the province of Sassari.



connections between the production system and all the downstream actors, who can participate in the promotion and valorisation of the product itself, has been hypothesized (Fig. 1)

Figure 1. Network hypothesis

The creation of the complex network of relationships would make it possible to achieve a governance of the local system, aimed at creating an alignment between tourist supply and demand, making the most of the wine tourism phenomenon. On the other hand, the Consorzio di Tutela seems to play a fundamental role in terms of expertise in tourism matters in the draft regulation that was approved by the Agriculture Commission of the European Parliament. In essence, an institutional role is assigned in the promotion of “PDO tourism” and tourist accommodation linked to geographical indication products. Therefore, Vermentino di Gallura DOCG, an expression of local identity, would guide the ecological and digital transition path of the entire system that revolves around it.

2.2 The role of BC within the Denomination of Origin production system, the core of the DAQ

The Consortium for the Protection of Vermentino di Gallura consists of about 40 producers, an area of 2,500 hectares, an annual production of about 6 million bottles, and 80 labels on the market. The target market for the wines is mainly local (70% regional and national) and the remaining 30% is especially intended for European and US markets. A very articulated and complex disciplinary (approved in 1996 and modified in 2014), subjects all the players in the value chain (especially the transformation industry) to strict control of compliance with wine production standards, including labelling. The DOCG is reserved for Vermentino di Gallura Superiore, sparkling, spumante, raisin and late harvest wines that meet the requirements established by the rules indicated therein. It is considered appropriate to recall some aspects of the specification itself, because it serves as a starting point in discussing the main function that a BC can assume within a DO: not only to avoid counterfeiting, adulteration, and use of excessive preservatives and hazardous chemicals, but also compliance with all production standards. This serves to make the entire process transparent, not only for

The Vermentino vine (equal to 4,850 Ha in Sardinia, 2020) is historically cultivated mainly in the province of Sassari, declined in the two denominations Vermentino di Gallura D.O.C.G. and Vermentino of Sardinia D.O.C. It can still be seen from the cartography that Berchidda, together with Alghero, is the municipality with the greatest concentration of cultivation of the Vermentino vine. The cultivation of Vermentino has been increasing over the years and between 2009 and 2020 it recorded an increase of 47%. As far as the details of Vermentino di Gallura are concerned, as of 2020 the following is recorded: surface area claimed equal to 1,317 hectares; grapes claimed 80,515 quintals; certified wine 31,645 hl (13% of the total certified DOP in Sardinia); bottled wine 28,010 hl. Between 1990 and 2020, the production of certified Vermentino di Gallura wine increased by 8%. Stocks in 2021 mainly concern bulk products (equal to 79% of the total stock in hl).

Having in mind the fundamental objective that gave impetus to the establishment of the DAQ, aimed at consolidating the networks of relationships between the various players that revolve around the valorisation of Vermentino di Gallura DOCG, a map of the possible

the benefit of the producers themselves but also for the benefit of the final consumer who has the possibility of verifying the guarantee of origin of the wine. The passages that it is considered important to underline, because they may represent critical issues within the system, are: the geographical origin of the grapes confined to the Gallura area (art.3), on land located at an altitude of no more than 500 meters above sea level, on which any forcing practice is prohibited and only emergency irrigation is permitted: this is an important issue because Vermentino is a vine that does not waste water; a minimum of 3,250 vines/ha is envisaged and the production of grapes/ha must not exceed 10 tons (9 for the superior type).

Moving on to the transformation phase, the minimum natural alcoholic strengths by volume are regulated, specific for each type of wine (variable from 10 to 12%, except in the passito type not less than 15%); the maximum yield of grapes in finished DOCG wine for consumption must not exceed 70%; if this limit is exceeded, but not 75%, the excess does not have the right to the DO, but over 75% the right to the DO for the whole product is forfeited; the maximum yield of grapes in wine for the passito type must not exceed 50% referring to fresh grapes. If the limit is exceeded, the excess does not have the right to DOCG but can be qualified with the IGT Colli del Limbara or Isola dei Nuraghi if it possesses the characteristics. The vinification, elaboration of sparkling wine, and bottling operations must be carried out within the delimited Gallura area. In accordance with article 8 of EC Reg. n. 607/2009, bottling and packaging must take place in the aforementioned delimited geographical area to safeguard quality, reputation, guarantee the origin of the denomination and ensure the effectiveness of controls. The problem arises with regard to the granting of individual authorizations according to the provisions of art. 10, (paragraph 3 and 4) of Legislative Decree 61/2010. This states that the delimitation of the bottling area must correspond to that of the vinification and/or elaboration area, including the derogations granted for the vinification and elaboration in the immediate vicinity of the delimited geographical area or in an area located in the administrative unit or in a neighboring administrative unit or, limited to PDO sparkling and semi-sparkling wines beyond the immediate vicinity of the delimited area, still within the national context, under the conditions established by specific Community legislation. It also provides that in the event of an application for protection for a new PDO or PGI, the same request must be representative of at least 66% of the surface of the vineyards, subject to declaration of production in the last two years; in the event of modification of the specification aimed at inserting the delimitation of the bottling area, the request must also be endorsed by a number of producers representing at least 51% of the production bottled in the last two years.

In this case, the bottling companies concerned can obtain the derogation to continue bottling in their plants located outside the delimited area for a period of five years which can be extended, on condition that they submit a specific request to the Ministry of Agricultural, Food and Forestry Policies, national DOP and IGP wines,

attaching suitable documentation to prove the bottling exercise of the specific DOP or IGP for at least two years, even non-continuous, in the five years preceding the entry into force of the amendment in question.

Release for consumption is permitted only from established dates: 15 January following the year of production of the grapes for base, superior and late harvest; May 1st for passito, December 1st for sparkling and sparkling wine. Sparkling wine obtained with the classic method cannot be released for consumption before the second fermentation of at least 9 months, with mandatory indication on the label of the date of first disgorgement. With regards to consumption characteristics, parameters of minimum total acidity ranging from 4 g/l (raisin wine and late harvest) to 4.5 g/l for all other types are envisaged; minimum non-reducing extract parameters variable from 14 g/l (sparkling and semi-sparkling), to 16 g/l late harvest, superior and base, to 24 g/l for passito. The packaging regulations contemplate the mention "vineyard" on condition that it is followed by the corresponding toponym, that the surface is clearly specified in the vineyard register, that the vinification and storage of the wine take place in separate containers and that this mention, followed by the toponym, is reported both in the declaration of the grapes, both in the registers and in the accompanying documents. For all types of wines (except fizzy and sparkling wines without indication of the vintage) it is mandatory to indicate the year of production of the grapes on the label. The Central Inspectorate for the Protection of Quality and Fraud Repression of agro-food products is designated by Masaf to carry out the annual verification of compliance with the provisions of the specification through a combined method of controls (systematic and random) throughout the entire supply chain production (viticulture, processing, packaging). The reference to production standards and control procedures, as has been said, is fundamental because it introduces elements of The main criticalities encountered regarding compliance with the rules of the specification are linked to the guarantee of the DO: specifically, the points of the process that must be monitored and traced concern: the place of production of the grapes, the place of transformation and the place of wine bottling. They are in fact elements that can escape strict control because it is possible to lose track of the path that the grapes take from the vine to the bottle. Producers are required to compile a vinification register in which to indicate all the operations carried out: origin of the grapes purchased outside their own company (it is compulsory to request the dossier registered in the National Agricultural Information System (SIAN) created by the Ministry of the agricultural, food and forestry policies and by the Agency for agricultural disbursements (AgEA) in which the cadastral data, the extension in hectares, the stumps and the vine are indicated); what route the grapes took, which carrier was used, day and time of departure and arrival; data on the transformation process from grapes into must; a preventive communication on the possible acidification process with tartaric acid, and so on up to the moment of bottling; the company file and all the reports of the grapes and the wine (made into wine, stocks in the cellar), are

shared with an information collection center, which in the case of Vermentino di Gallura is represented by Confagricoltura. At the time of bottling, the producer is obliged to call the certification body, Agroqualità in the case under study, which carries out the sampling, subjects the sample to tasting analysis and if the commission believes that the parameters of the specification are respected by the approval for the purchase of the bands to be affixed to the cap. Despite this process control scheme, albeit synthetic, there are cases of counterfeiting with volumes of bottled wine that do not correspond to the regulated quantity of grapes per hectare, for example; frauds are almost always discovered, but what one would like to avoid is that they can be implemented.

The introduction of a certification and writing in BC combined with the digitization of all phases of the production process could solve some of the internal problems of the system; facilitate checks by the body in charge. At the same time it would respond to the purpose of allowing the intermediate and final consumer to verify the composition of each lot/bottle of wine along the entire supply chain from the grape growers to the retailers. In fact, the DO guarantee itself, carried out through this tight control, remains known to the production system, but is not communicated to the consumer in a transparent manner. Even today there are consumers who do not know the distinction between DOC and DOCG or IGT. The registration of the critical phases of the process in the BC, with the help of a platform that collects data from all producers, could make it more complicated to fail to comply with production standards, and put the consumer in a position to know the origin of the bottle as well as accessing production information.

2.2.1 The BC Technology used

The type of BC that is analyzed in this study is the consortium one, in which the control takes place by a group of members: the verification and addition of records to the BC is based on a consensus mechanism by a pre-selected set of nodes (e.g. in regulatory decision-making) [22].

The production system is characterized by the presence of: independent winemakers or those associated with a cooperative winery; processing-only industries (without vineyards); pure bottlers; fully (they have direct control of all stages of the production process) or partially (if they also buy grapes from others) integrated industries and cooperative wineries (Social Cellars in Monti, Berchidda and Tempio). Most of the producers then join the Protection Consortium, leader of the DAQ. Therefore we can hypothesize different paths of use and writing in BC according to the specific objective that it is necessary to subject to control.

2.2.2 Implementation hypothesis in cooperative enterprises

Let's build our hypothesis considering one of the cooperative wineries located in the Gallura area: founded in 1956, today it has 350 members who cultivate

500 hectares in the territories of Monti, Telti, Olbia, Loiri Porto San Paolo; the processing industry carry out the production process from crushing-destemming to storage in thermo-conditioned rooms. The barrel cellar welcomes visitors interested in learning about the evolution in barrels (from 2500-500 litres) and the refinement in the bottle of the wines produced; a total of 16 labels (4 types of white, 3 red, 2 brut, white and rosé, one sparkling, one moscato, one grappa, one myrtle and 3 magnum versions of the main wines). Three of the white wines are produced with 100% Vermentino di Gallura vine. In order to guarantee the transparency of the production cycle in compliance with the production standards, one could hypothesize a certification in which the entire wine production chain is traced and registered in BC.

All the actors must write the activities, that are carried out in each phase of the supply chain in a ledger, everyone declares and digitally signs the product that is transferred to the next phase at the gate of their own process phase. This step shouldn't be complicated given that producers are required to fill in the winemaking register and some have already computerized the writing. The bottle, or six-bottle carton, is the one that will reach the intermediate and/or final consumer and is also the one that can be monitored to verify all the characteristics necessary to ensure compliance with the production specification. In a hypothesis of writing in BC, declared on the bottle with a logo designed *ad hoc* by the consortium itself, and accessible to the consumer via a device to be studied (a code, a QR code or other to be established on the basis of available IT innovations) the chain will be the following.

The first block concerns the production of grape, and the records that the grape growers should keep in the chain are those required by the specification, or which allow to certify the compliance: geolocation, surface area, grape variety, planting sixth, emergency irrigation (YES/NO), use of fertilizers and pesticides, pruning, production per hectare, harvesting method (manual or mechanical) and harvest date. Furthermore, as they are responsible for transporting the grapes to the cellar, this step must also be recorded indicating the time of departure from the vineyard, the time of arrival at the cellar, and the quantity (and quality) of grapes delivered. The second block is represented by the transformation industry (this receive grapes and perform a number of procedures and operations to produce wine): to ensure traceability, records on the processes and raw materials used to make the wine should be insert in the chain. This includes suppliers'details, quantity of grapes coming from partner vinegrower X, wine/tank for which the batch of grapes is intended (so as to indicate in what % the partners have contributed to producing that given wine), the wine yield, the title alcoholic strength, the minimum variable total acidity, the minimum non-reducing extract, year and month of grape production. It also records in the ledger all the operations carried out in the cellar (fermentation, conservation and refinement) chemical contents.

At this point the wine is ready to be sold and can follow two paths: that of bulk wine, which is still in use not only among cooperative wineries but also among

individual ones, or that of bottling. In both cases the wine can be destined for the wholesaler or the retailer which in turn can be a wine shop or a local restaurant/agritourism. If it is bulk wine, the distributor must record the quantity of incoming product, guarantee that the wine is sold to the final consumer with the wording Vermentino di Gallura, declare the quantity sold and the information must be recorded in the chain. This becomes the third block (a).

In the case of bottling, the place of bottling, the number of the bottle with the finished label, the number of bands purchased following the (random) inspection carried out by the certifying body (Agroqualità) must be recorded. When the six-pack cartons of bottles leave the cellar, they must be registered on exit with date and time, transport carrier, date and time of arrival at the retailer (which can be, not only wine shop or a local restaurant/agritourism but also GD). This becomes the third block (b). As specify by [23] “the retailers are responsible for keeping details of the received items, storage, and sale information. Upon storing the information on the blockchain, a consumer would be able to see the provenance of the purchased wine by putting the identification number on the website” (p. 57). When a bottle or carton is sold the information has to be recorded in BC so it is no possible to use the same label again. In addition, retailers are responsible for keeping details of the received items, storage, and sale information. If the information is registered in BC, the consumer is able to check the origin of the wine purchased by simply entering the identification code on the company's website (in this case the Cantina Sociale should host a page dedicated to the BC certified product on its website, through which individual users can access the information registered with BC for that particular reference of Vermentino di Gallura).

With the aim of tightening control over the movement of grapes and wine, it would be appropriate to include a fourth block in the BC represented by the Protection Consortium which confirms the legality of the grape and wine production practice; a fifth block, represented by Confagricoltura which confirms that the production reports have been duly carried out; a sixth block represented by Agroqualità, which independently confirms the legality of the process (grapes and vinification, bottling), a seventh block, represented by the ICQRF which needs to maintain consistency of BC in information and corresponding physical product. At this point the sophistication process would be too complicated as well as expensive and the presence in BC of the institutions involved in the control process becomes a deterrent.

Since the registrations involve the disbursement of a fee, the registration of all the individual steps could be too expensive and not even be necessary: a digitization system of the whole process could be supported, all the players (winegrowers, transformation company, Confagricoltura, Agroqualità, ICQRF) can be profiled within a web platform or in a mobile App, in which to collect all the information (all the players can access the site and register the information directly); the platform then becomes one large shared ledger, accumulating and

delivering big data. This system would also make the monitoring process carried out by the certification and control bodies more streamlined and easier because the information is available via the web and in real time, but also by the Consortium itself, which having the erga omnes can exercise the its action towards all producers (even non-members) and is authorized to verify compliance with the specification and request for each producer all the data necessary for control. Another relevant advantage is that in this way the transaction costs of the control operations are reduced and this decentralized structure appears reliable and consequently immune to potential cyber attacks.

2.2.3 Implementation hypothesis in single cellars totally integrated

The second most frequent typology in the Vermentino di Gallura production system is represented by the company with its own vineyard that vertically integrates all phases of the production process, including services to the public with tastings and lunches in the cellar, alternative and innovative activities such as wine therapy, production of face and body creams made using grape processing residues (marc), cooking classes, various cultural events. Let's take for example one of these companies located on the outskirts of Olbia, immersed in the vineyards that operates with the utmost respect for environmental sustainability: the vineyards are cultivated by practicing the integrated agriculture system, herbicides are not used, treatments are limited and are carried out exclusively with products with low environmental impact. The company is SQNPI certified (National Integrated Production Quality System) and Green Care (reduction of water and electricity consumption). The plants are not irrigated, except with emergency irrigation, this also allows their roots to go deep in search of water, absorbing minerality and character from the granite and sandy soil. The workings of the vineyard are still the traditional ones of hand pruning and binding with natural material. The harvest takes place strictly by hand and the grapes are transported in small boxes inside the cellar. No use is made of animal-derived products or by-products either in the vineyard or in the cellar and wines are 100% Vegan. The cellar is located in the center of the vineyard and provides for the vinification and bottling only and exclusively with grapes of its own production.

The construction originates from an ancient building, completely renovated bringing out the original structure in granite stone. The technical area is modernly equipped with steel tanks and is divided into various operational zones. The containers in the aging room below are filled without using pumps to further safeguard the integrity of the wine. This mix of ancient and modern, tradition and innovation, distinguishes and gives character to the cellar and wine production.

The company also stands out for being inclusive, being the entire cellar, including the cellar, accessible to people with motor disabilities. It produces 9 references 1 still white wines produced with 100% Vermentino di Gallura Superiore grapes, 1 with 100% Vermentino di

Gallura late harvest, 1 brut sparkling wine always with 100% Vermentino di Gallura grapes, 1 white wine with Vermentino di Sardegna DOC grapes, 1 rosé, 1 red, 2 IGP reds, 1 spoon wine.

Let's consider the production process of the 100% Vermentino di Gallura Superiore wine, with an espalier training system, manual harvest, in small boxes, carried out in the first ten days of September. After a soft vacuum pressing of the grapes, the must is suddenly cooled and clarified by cold decantation. Then begins the slow fermentation at a controlled temperature in steel containers. During the aging process the wine is kept on the lees for at least 8 months in steel. The capping is with a glass stopper, and the alcohol content of 14% vol.

The company keeps an electronic winemaking register, the ledger, in which it describes all the steps in the process of transforming grapes into wine: quantity of grapes produced, yield of must, quantity of must in fermentation, of new wine in fermentation and wine ready for consumption. With regard to any acidification process carried out with tartaric acid, prior communication is given to the control bodies at the time of harvesting; the date and time are indicated for all operations. The by-products of the processing (stems and pomace) are scattered in the field, from when the legislation allows it (before they were sent to the distillery) and in any case the control bodies must be notified to indicate exactly in which cadastral map the by-products will be disposed of. The integrated/organic production process is subjected to even stricter controls: surprisingly, every year Agroqualità carries out checks on the chemical residues contained on the grapes, leaves and must; Agroqualità itself keeps registers in which it writes all the information; the samples taken and sealed are sent to a laboratory outside the region (Veneto, Sicily) and always different for carrying out the analyses. At the time of bottling, as in the previous case, the certification body is notified, which takes the sample, to send it to the tasting commission.

The registration of the whole process in BC in this case is facilitated both by the presence of the digital ledger and by the fact that everything is centralized within a single block: rather than recording all the steps which in any case have a cost, in this case it is possible to proceed with a single registration which carries a full-bodied message with saving of money. Also in this case, after the first block, represented by the company, the other institutional control blocks follow, with the aim of confirming the legality and transparency of the entire production process.

All individual companies are profiled within the common platform built ad hoc for the production system of Vermentino di Gallura: even with the possibility of interfacing the instrumentation used with the platform itself (for example when weighing the grapes, the scale can be digitized and the information is directly transferred and accumulated in the dashboard). All companies that agree to sign the BC can use the *brand* which must obviously be the same for all consortium members. The importance of expanding BC is linked to its success in terms of objectives, because as [17] underline, the “network effect” occurs and benefits are

dependent on a critical mass of supply chain actors adopting the technology.

As already specified, there are other types of companies such as pure winemakers and pure bottlers; for these categories the registrations already indicated above are valid. Furthermore, as highlighted by [23] in addition to these supply chain figures, others are added: “1) *Raw material suppliers-responsible for providing all the supplies needed for grape growers, wine producers, fillers/packers*; 2) *Freight operators- responsible for transporting goods from wineries or packers to importers or to other entities (distributor, wholesaler, retailer, etc.)*; and 3) *Importers- responsible for buying goods from the wine producer, selling and delivering finished goods to the wholesaler or distributor of the destination country on the basis of the distribution channel*” (p. 57) which however in this phase of the research are not taken into consideration.

2.3 Hypothesis of extension of the BC to the DAQ of Vermentino di Gallura D.O.C.G.

Taken as a whole, the objectives of the DAQ to be set up are above all of a planning nature. In very general terms, in fact, we want to proceed with planning and implementing joint strategic actions to introduce production and marketing standards shared with all the players who will become part of it; adopt technical and technological innovations in respect of tradition; strengthen the wine supply chain internally and in relations with other local supply chains; promote the territory and its products with marketing and communication actions; to encourage the sustainable mobility of production and a sustainable and supportive economy.

Specifically, the Promoting Committee of the DAQ of Vermentino di Gallura DOCG has the objective of organizing and structuring a project proposal informed by the following actions and objectives:

- implement local program governance with a general and integrated project, in order to pursue collaborative planning and implementation between local communities and the Vermentino di Gallura DOCG production system;
- support the reconversion and/or redevelopment and/or modernization with particular reference to the programs-projects-actions necessary or appropriate for the green transition and the digital transition of the area affected by the production of Vermentino di Gallura DOCG;
- strengthen development actions in the area, including those already underway and consistent with the general objectives assumed by the district, through the active participation of the communities and the involvement of the various components of the local culture, economy and society;
- placing the local wine sector at the center of the growth process, developing and encouraging investments for the practical application of social, environmental, economic and intergenerational sustainability plans;

- enhance the marketing of wine products and their derivatives through direct sales channels and promotion of local production with the most modern marketing tools and digital sales channels;
- conserve and enhance the historical-cultural heritage and environmental resources, according to the principles of sustainability, initiating and/or integrating paths aimed at stimulating the accommodation system and new forms of tourism, up to new forms of stay, including seasonal ones.

In this case, the idea would be to build a BC of the DAQ, including in the chain hypothesized for the nucleus of the district, all the players who to some extent use Vermentino di Gallura for the purpose of promoting it for wine tourism and gastronomy. In addition to restaurateurs, there is talk of including pasta factories, for example, that use Vermentino to produce special pastas and so on; all stakeholders will be able to use the brand if they are willing to build a block to add to the chain, and record all the information necessary to carry out checks on the raw material used, production process and quantities sold. In addition to extending the traceability of the use of Vermentino di Gallura, the intention is to produce a sort of DAQ specification, in which the strict criteria of environmental, social and economic sustainability are respected and can be quantified.

This represents a further evolution of the present research still in progress.

3 Concluding remarks

BC technology is still in its infancy and faces its own challenges, not least in terms of the huge amounts of energy consumed by the underlying technology, but also in terms of implementation costs.

The work aims to contribute to the debate on the utility deriving from the digital transition process of the economy in general, with specific reference to viticulture. The wine industry is among the most studied sector in literature concerning the application of BC and other digital tools to the agri-food [10].

The reasons for this attention can be partly related to internal characteristics and needs of the sector, partly to the opportunities that BC offers to meet these needs.

The innovative aspect within the existing literature is represented by the fact that in this case it is not a question of applying BC's writing to a single company (mono-objective), but to the protection of a designation of origin and the guarantee of compliance with a Production Disciplinary, still little studied in the wine sector.

The criticality of the study is linked to the fact that it is a study still in progress, even if at an advanced stage of conception: there is already a project idea to be submitted to a request for funding in partnership with a company that produces software, Innovyou, and which operates in Sardinia, specializing in the construction of BC.

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