Sustainability determinants in the Iberian wine industry

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Abstract

The objective of this study is to determine the factors that explain the orientation, of the wine industry and at firm level in Portugal and Spain for adopting policies to improve sustainability, identifying similarities and differences between the two countries. The study focuses on two countries that account for a relevant part of the global vineyard surface area, wine production and wine exports. The database for the empirical analysis has been constructed through a survey conducted among wineries of the two countries during 2020 and 2021, for which a total of 568 valid responses were obtained, 151 in Portugal and 417 in España. From the quantitative analysis, based Box-Cox left-hand-side models, one for each country, it can be concluded that those wineries that invest the most in their growth, anticipate future challenges and interact with interest groups are more inclined towards adopting sustainability measures. The study also reveals notable differences between the two countries as the determinants that drive sustainability, finding that sustainability policies are not unit and specific common vectors.

***Keywords**: Sustainability, Wine industry, Box-Cox model.*

1. Introduction

The concept of sustainability balances the different dimensions of development (environmental, economic, and social) that define the quality of human life in its broadest sense. It is an important and complex issue to be incorporated into grape production and winemaking operations (Bryceson and Ross, 2020; Elkington, 1994; Meynard *et al.*, 2017; Schader *et al.*, 2014; Vasileiou and Morris, 2006; Costa *et al.*, 2022). Since 2004, the sustainable wine industry has been defined by the International Organisation of Vine and Wine (OIV) as a global strategy implemented in the grape production and processing systems, which incorporates the economic sustainability of structures and territories and produces quality products considering the environment, product safety and consumer health. The concept not only refers to ecological

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elements but also to heritage, historical, cultural, and aesthetic aspects, clearly affirming that the wine sector incorporates all the intangible aspects that characterise wine as a product of excellence (Hospido *et al.*, 2022).

Indeed, the wine sector uses and has an impact on natural resources and is one of the most prolific users of phytosanitary products in agriculture (Aubert and Enjolras, 2014; Pinto *et al.*, 2022). Concerns about environmental aspects have been circumvented by the adoption of organically certified agricultural production which is perceived as a sign of quality in general (Pagliarini *et al.*, 2013), and, as indicated by Behmiri *et al.* (2019), the winemaking industry has become subject to changes in terms of its production, consumption patterns and international trade. The growing interest of consumers in environmental certifications has recently been confirmed by the VINOVERT experience and it seems that consumers value the efforts of producers (Pinto *et al.*, 2022), and that a more organic and integrated production system will encompass more preventive rather than reactive actions and strategies (Costa *et al.*, 2022).

However, these modes of production do not address the environmental impact of the product throughout its whole life cycle. Hospido *et al.* (2022), and Costantini *et al.* (2016) report that the impact on the overall production system and vineyard farm organisation of vine growing has been studied only recently. Vine and wine production require great amounts of energy and involve a series of activities that sequestrate and emit carbon dioxide (CO2), among other gases (Teissedre *et al.*, 2022). The use of chemicals is also significant in wineries for cleaning activities and wine preservation (Costa *et al.*, 2020).

Currently, wine companies are exploring how to incorporate sustainability into their business models (Broccardo and Zicari, 2020) in order to adjust them to customer and stakeholder preferences (McGrath, 2010; Provance *et al*., 2011). Therefore, due to this increased pressure from stakeholders and economic or political reasons, sustainability has become a paradigm that requires clarification and an understanding of its definitions and principles (Hospido *et al.*, 2022). The presence of an economic dimension that requires feasibility, a social dimension that involves acceptability and an environmental dimension that needs carrying capacity have been recognised by Gerdessen and Pascucci (2013) who argue that the multidimensional perspective is the one way of dealing with the complexity of measuring the concept of sustainability. Recently, Trigo *et al.* (2021) added four fundamental principles for sustainable agriculture that includes integrated management, dynamic balance, regenerative design and social development, and the authors conclude that to shift our current agricultural systems into more efficient and sustainable ones, we need to start making better use of natural and human resources.

In this domain, the definition of territorial contexts is also important because the specificities of the local culture, society and economy have to be taken into account in order to implement and articulate sustainability (Borsellino *et al.*, 2016; Trigo *et al.*, 2022; Zanoli, 2007). This statement is supported by a cross-country analysis by Flores (2018) about current sustainability assessment frameworks in six countries. It showed that there was convergence in the main criteria adopted by the frameworks, but the proposition of general guidelines for sustainability assessment was a hard task due to the local conditions. Trigo *et al.* (2022) find that a holistic understanding and an assessment of complex systems in their environments are required in order to introduce sustainability in all its domains and to ensure the long-term viability of any agricultural system (Dantsis *et al.*, 2010; Gilinsky *et al.*, 2016).

Within this context, the objective of this study is to determine the factors that explain the orientation of wineries in Portugal and Spain for adopting policies to improve sustainability, identifying similarities and differences between the two countries. As we will explain below, these countries are two highly relevant actors in the global production and trade of wine. Therefore, our study can provide important lessons not only for understanding the business strategies used in terms of sustainability in the wine industry and its determinants in other countries but also for other agri-food industries in gen-

eral. One of the strengths of our study is that it is based on information obtained from surveys carried out directly among the wineries of the two countries, with very high coverage of the industry as a whole. With the data obtained from these surveys, we propose an econometric model that enables us to determine the most relevant factors for explaining the orientation of the wineries in the Iberian countries in order to achieve greater sustainability.

The study is structured as follows. Section 2 explains the relevance of the study chosen and conducts a review of the existing literature on the sustainability of the wine industry in Portugal and Spain. The third section establishes the hypotheses that we wish to verify with the empirical study. Section 4 presents the materials and methods used. The following section present and discusses the results obtained and the final section summarises the main conclusions of the study.

2. The wine industry in Portugal and Spain and literature review on sustainability

2.1. *The wine industry*

Portugal and Spain are two of the most relevant countries of the so-called Old World Wine, with a long producing and exporting tradition (Fernández and Pinilla, 2018; Lains, 2018).

Currently, Portugal has the fourth largest area of vineyards in Europe, with 194 thousand ha in 2021. In the same year, wine production was 7,3 Mill. hL. It was the tenth global exporter in terms of volume and ninth in terms of value. Spain is the country with the largest area of vineyards in the world with 964 thousand ha in 2021, although, in terms of production, it holds third place with 35,3 Mill. hL. In 2021, it was the leading exporter in terms of volume, representing 21% of the world total, but only third in terms of value, with 8.4% of the global total (OIV, 2022).

In terms of organic wine, although it is produced throughout the national territory, there is still room for a lot more growth in Portugal. The area under organic vines as a share of the total area is around 2%, with 4,000 hectares of organically cultivated vineyards. The average annual growth rate, over the period 2014-2019 of the area under organic vines was 8% (OIV, 2021b). The national production of organic wine has been increasing and most of the production corresponds to red wines with Protected Geographical Indication (PGI) and Protected Designation of Origin (PDO). Since the demand for organic products is growing more than the production in Europe, it is expected that the Portuguese production of organic wine will continue to increase (IVV, 2022).

Spain's organic wine is arousing increasingly more interest due to the efforts to promote more sustainable agriculture. In 2019, the area of ecological vineyards in Spain reached 121,290 hectares, that is, 13% of the country's total vineyard area and 26.9% of the world's ecological wine production area. Spain holds the first position in terms of the area of the ecological vineyard, above Italy, France and China. This type of crop has not stopped growing in recent years, with a sustained expansion of hectares: between 2009 and 2019, the area of ecological vineyards almost tripled, from 53,958 to 121,279 ha. Furthermore, the number of wineries making this type of organic wine has risen from 408 to 1,152, representing 13.9% of total wineries (OIV, 2021a). However, one of the elements which have proved to be relevant concerning the consumer is the identification of organic or sustainable wine. This has yet to be fully developed and, an example of this is the existing certifications. The Spanish Wine Federation (FEV) grants sustainability accreditation with the name "Wineries for Climate Protection" which, in May 2021 had been given to 32 wineries (FEV, 2021). The association Spanish Organic Wine groups together small wineries that make organic wine has the objective of promoting these wines abroad given the difficulties encountered in the domestic market. In May 2021, there were 39 associated wineries (Spanish Organic Wine, 2021). It seems, therefore, that although the first steps have been taken, there is still a long way to go for wine and wineries to be positioned as sustainable and enjoy the advantages of being recognised as such by the consumer (Sellers and Nicolau, 2016).

2.2. *Literature review on sustainability*

Although sustainability in the Portuguese and Spanish wine industry is a topic of growing interest for researchers, the available studies are still very scarce and limited in terms of sustainability dimensions, geographical contexts, and value chain links. The environmental dimension has received the most attention in the literature and incorporates the concerns about the impact of climate change on the potential yield of grapes. These studies have been conducted to define adaptation and mitigation measures.

More specifically, the projected warmer and drier climate is expected to have detrimental impacts on grapevine physiology and potential yields of the vineyards, although these crops are considered climate-resilient. To contradict and mitigate these projections, the application of suitable adaptation measures is suggested, such as the improvement of crop water use efficiency and the adaptation of mulching (Fraga *et al.*, 2022).

However, the expansion of the irrigated area could put pressure on local water resources. Water use and wastewater generation in irrigated viticulture and wineries remain insufficiently quantified, particularly in southern Portugal and are often disregarded as best practice (Costa *et al.*, 2020; Matos and Pirra, 2020). In the case of Spain, a very fast increase in the blue water footprint has been observed from 1995, which has multiplied six-fold in twenty years with an extreme concentration in the region of Castilla-La Mancha, which accounts for 70% of this increase. The expansion of irrigated vine growing in this region has played a relevant role in the serious problems suffered by its aquifers (Ayuda *et al.*, 2020).

From an environmental perspective, studies that apply the life cycle assessment (LCA) approach are predominant in Iberian countries. For a white wine produced in the northern coastal part of Portugal, Neto *et al.* (2013) find that viticulture is the stage with the largest relative contribution to the overall environmental impact (more than 50%) and bottle production is the subsequent stage (varying from about 4% to 26%). However, for Martins *et al.* (2018) in the Douro Wine Region, bottling and storage made the highest contribution to the carbon footprint, material intensity, solid waste and wastewater, while viticulture made the largest contribution to water consumption. The largest contribution to energy intensity (94%) was made by the winemaking stage, mainly due to the transportation of grapes to the winery and wine to the bottling facility. For La Rioja (Spain), Gazulla *et al.* (2010) find that the stages with the greatest environmental impact in vintage winemaking are viticulture and the production of the glass for the bottles. For the same type of wine in Catalonia (Spain), Meneses *et al.* (2016) conclude that the glass production stage has the greatest environmental impact. Villanueva *et al.* (2014) for Ribeiro wines (Spain) and Vázquez *et al.* (2012) for Rías Baixas wines (Spain) conclude that a reduction in the levels of the consumption of material inputs (diesel, phytosanitary products and fertilisers) translates into a reduction of the environmental impacts in production. Martins *et al.* (2018), working with six environmental sustainability indicators perform a comparative sustainability evaluation of two Portuguese wines – a branded wine and a "terroir" wine, produced by the same company but differing in their production process, the volume of production, and market value. The main differences observed were related to the water intensity and wastewater generated, which were more than double for the branded wine. The authors attributed such differences to the winemaking process.

The work of Santos *et al.* (2019) dedicated to comparatively evaluating the sustainability dynamics in the North and Alentejo regions of Portugal was based on 32 environmental, economic, and social indicators using the Portuguese Farm Accountancy Data Network from 2001 to 2012. The results showed that Alentejo performed the best in terms of environmental sustainability while the North had an increasing economic dimension of sustainability and good social performance.

A more holistic approach has recently been developed in the studies of Pino (2021) and Marta-Costa *et al.* (2022). The first presents a functional and adequate methodology, capable of facilitating the identification, selection, and aggregation of the set of indicators, in a balanced triple bottom line perspective, defined and adapted to a wine firm in northern Portugal with more than 150 years of history and with a turnover of around 40 million

euros. The model used incorporated 36 indicators and was applied to evaluate the sustainability of the firm between 2017 and 2020 and an average sustainability index of 82 (out of 100) was achieved. The second study, applied in the geographical context of the Douro, was a benchmarking study of sustainability performance using three assessment approaches – MESMIS; INSPIA, and the Triple Bottom line. Although the results are better when the indicators are aggregated into a composite index by the MESMIS or INSPIA assessment approaches, the low productivity of the Douro winegrowing systems is noteworthy and puts the Douro wine region in a weak position, which coincides with previous studies based on the intrinsic local and regional difficulties such as its limited geographical accessibility, remoteness and topography, and the higher production costs per hectare (Graça *et al.*, 2017; Santos *et al.*, 2019).

Ferrer *et al.* (2021) identify two business models among the Spanish wineries. The high sustainability business model is based on the ownership of a vineyard, the production of bottled wine, with sales in retail stores, supermarkets or through intermediaries, a better online position than the competition and a relevant positioning in the premium segment and exports. The business model of a less sustainable winery is based on the sale of bulk wine in the most economic segment and an unawareness of where the wine is sold. García-Cortijo *et al.* (2021) conclude that adopting sustainability policies requires emphasizing innovation and on the capacity for communicating such innovations so that consumers perceive them as a change for the better.

As already mentioned, sustainable development is an incremental process on an economic, environmental and social level (Mariani and Vastola, 2015, Swiatkiewicz, 2021). In this respect, a balance must be found between the three dimensions, without forgetting that scarce financial resources hinder the development of sustainable strategies, particularly for small and medium-sized wineries, which consider sustainability as an investment with little financial return, reducing their motivation to shift in this direction (Broccardo *et al.*, 2023; Burlea-Schiopoiu and Mihai, 2019; Akben-Selcuk, 2019, Lee and Lee, 2019; Masurel, 2007). Markman and Krause (2016), Ostasiewicz and Ostasiewicz (2017), on the other hand, indicate that activities aimed at sustainable management should first consider the natural environment, second, the social aspects and third, the economic results. In any case, if the wineries do not have a minimum economic profitability, the environmental objectives will be difficult to achieve (León and Varela, 2011). In this respect, Rey (2020) proposes a series of measures to achieve economic sustainability in the wine business: a) good accounting practice, b) not selling cheaply what is expensive to produce, c) segmenting the markets correctly and adapting the products to these segments, d) obtaining the necessary finance and e) ensuring smooth generational transfer in the companies. Further actions include the concepts of shared value, green intellectual capital and the circular economy. The creation of shared value introduces an approach that reinvents products, markets and the value chain (Mutis, 2015; Moore, 2014; Porter and Kramer, 2006). On the other hand, investment in green intellectual capital promotes the knowledge of the benefits associated with sustainability and competitiveness (López-Gamero *et al.*, 2011; Yong *et al.*, 2019; Marco Lajara *et al.*, 2022; Journeault *et al.*, 2020). Finally, the wineries indicate circularity initiatives as a way to reducing waste and the consumption of new resources, which would improve their image and generate the corresponding economic benefit (Lara, 2022).

3. Research hypothesis

In order to fulfill our objective of identifying the determinants of the inclination in Portugal and Spain to adopt sustainability policies in the wine industry, we have established three hypotheses that we will attempt to verify. These hypotheses seek to reveal whether concern about adopting policies to improve sustainability is determined by: 1) the search for the growth of the firms through investment, 2) the challenges that these firms believe that they will face in the future, 3) interaction with agents of interest and, 4) the impact of extraordinary events, such as the Covid-19 health crisis. As well as establishing which of these variables has been the most important, without being mutually exclusive, we will seek to identify the similarities and differences between the two countries.

Companies need to grow and obtain profitability (Jeewandarage, 2021). But the very objective of the growth of companies is at odds with sustainability, leading firms down a type of dead-end (Edwards, 2021; Ehrenfeld, 2005; Bermejo Gómez de Segura, 2014; Ruggerio, 2021). Therefore, for example, the intensity with which climate change is affecting the planet requires an equilibrium to be reached between sustainability and economic growth. In this dilemma, firms are fundamental actors, given that the adoption of sustainability policies can affect their results in the short term (Chan *et al.*, 2022; Moore and Manring, 2009; Gupta *et al.*, 2013). The compatibility between the growth of the company and sustainability is, therefore, a fundamental aspect, as it is reasonable to believe that this compatibility requires investments to be made in the different stages of production and the modification of the current production system. Therefore, we can establish our first hypothesis:

H1: The interest of the wineries in adopting policies aimed at improving their sustainability is determined by the investments that they intend to make to ensure their growth.

There are many challenges in the wine chain; therefore, wine producers are concerned about improving the technical and qualitative aspects of their products, their knowledge of the market, the demand and their competitors (Pesme *et al.*, 2021; Menghini, 2015). In addition, there are environmental challenges due to the pressure of consumers and citizens (Bordeaux Sciences Agro, 2022), for which financial challenges are proposed (De Steur *et al.*, 2020; Barbosa *et al.*, 2018; Ouvrard *et al.*, 2020). The concern for these challenges which the firms expect to face can also lead them to adopt a greater orientation towards sustainability. Our second hypothesis to verify is:

H2: The interest of the wineries in adopting policies aimed at improving their sustainability is determined by the challenges that they consider they will face in the immediate future.

The framework of sustainable winemaking is a response to the demands of society, of clients and markets and a strategic way of positioning the territory (Marco Lajara *et al.*, 2022). This is why the behaviour of a company in terms of its sustainability policy is increasingly related to its relationship with the different interest groups (Grunwald *et al.*, 2021; Sharpe *et al.*, 2021; Uribe *et al.*, 2018; Birnbaum, 2016; Gil and Paula, 2016; Fernández and Bajo, 2012). Sustainable companies should know their stakeholders, promote dialogue, meet their demands and expectations and be transparent. Following Barnett *et al.* (2018) and Marco Lajara *et al.* (2022), who suggest necessary collaboration between companies, public administrations and other interested agents for a correct environmental management, this study considers the following interest groups: public administrations, regulating councils, other wineries and suppliers and clients. In this respect, the third hypothesis is established:

H3: Relations with economic agents is an important factor for carrying out the sustainable policies of wineries.

Finally, a special feature occurring in the period studied (Simon *et al.*, 2015) and which could affect the sustainability of the sector is analysed: Covid-19. As in almost all spheres of the economy and society, Covid-19 has had a serious impact on the different components of the wine industry (Witter and Anderson, 2021; Dubois *et al.*, 2021; Compés *et al.*, 2022; Rebelo *et al.*, 2021). Arora (2020) indicates that the negative impact of Covid-19 on the economic situation led the wine industry to relegate climate change to a second level in this period. Other authors such as Niklas *et al.* (2022) indicate that the perception of the impacts produced by the Covid-19 crisis has depended on the different business models in the wine industry, with that of the Old World wine countries being more resilient to its impact than that of the New World countries. In this respect, the fourth hypothesis is established as follows:

H4: The Covid-19 health crisis influenced the orientation towards sustainability of the wineries.

The next section presents the materials and methodology used.

Table 1 - Margin of error of the sample.

Region	*Sample*	*Population*	*Significance of sample*
	No. of wineries	*No. of wineries*	*Margin of error*
Portugal	151	1,017(1)	7,4%
Spain	417	4,142(2)	4.6%

Source: own elaboration. [(1)]Banco de Portugal (https://www.bportugal.pt/QS/qsweb/Dashboards) and [(2)]SABI (https://sabi.informa.es/version-20230105-3378-0/home.serv?product=SabiInforma&) for Spain.

4. Materials and methods

4.1. *Sample and variables*

In order to answer the research questions, it is used database companies that operate in Portugal and Spain, whose main economic activity is winemaking. All of the wineries acting as independent companies and operating at the time of the survey were selected. The managers of each of the companies were contacted by email (Spanos and Lioukas, 2001; Ortega, 2010). The wineries were given one month to reply and if in that time no response was received a follow-up phone call was made. The final sample was made up of 151 wineries for Portugal and 417 for Spain, with a sample error of 7.4% and 4.6% respectively. Taking into account that the general rule in terms of the acceptable margins of error in survey research is 5% to 10% (Islam, 2018; Suresh and Chandrashekara, 2012; Fleiss, 1981), the sample is representative of the total population (see Table 1).

4.1.1. *Dependent variable. Sustainability index*

As the objective of the study is to identify the variables that influence the sustainability policies of the wineries, the dependent variable has been defined based on an indicator, $Y_{SUSTAINABILITY}$, observing the three-dimensional nature of sustainability (Broccardo *et al.*, 2023). Therefore, the index $Y_{SUSTAINABILITY}$ is the sum of the representative items of the pillars of sustainability: the return of assets (Y_{ROA}) for the economic dimension; the carbon footprint ($Y_{FOOTPRINT}$) for the environmental dimension; and corporate responsibility ($Y_{CSR.}$) for the social dimension.

Therefore, its analytical expression is:

$$Y_{SUSTAINABILITY} = Y_{ROA} + Y_{FOOTPRINT} + Y_{CSR}$$

The return of assets (Y_{ROA}) is an indicator used by researchers to measure profitability, performance and the value of companies. It has been used for companies in general (Jarvis *et al.*, 2000; Dewenter and Malatesta, 2001; Damodaran, 2002), the agri-food industry (Schiefer and Hartmann, 2008), the wine sector (Amadieu and Viviani, 2010); studies on France (Bresciani *et al.*, 2016); California, India and Italy (Gilinsky *et al.*, 2010) and Spain (Sellers-Rubio, 2010; Simon *et al.*, 2015; Soler *et al.*, 2017).

The carbon footprint ($Y_{FOOTPRINT}$) has been one of the most widespread indicators for assessing the environmental effects of food production and consumption (Scrucca *et al.*, 2018) and the publication of ISO 14067 has standardised the methodology for its quantification, including wine (Hospido *et al.*, 2022). Point *et al.* (2012) find that bottling and distribution logistics are highly carbon-intensive and account for around 50% of the CO2 generated throughout the supply chain.

Corporate social responsibility (Y_{CSR}) can be a requirement for competitiveness in the medium and long term and a major issue for future market positioning (Pinto *et al.*, 2022). This recommendation had already been made by Pomarici and Vecchio (2014), who indicate that market and regulatory forces should be directed towards reducing and communicating the environmental and social performance of the wine sector. Corporate sustainability requires socioenvironmental practices that can reduce the negative impacts of the wine industry and which are aligned with their economic objectives (Szolnoki, 2013; Taylor, 2017).

Each dimension has been quantified based on a Likert scale, with values 1 to 5, both inclusive. Cronbach's Alpha ζ has been applied to estimate the internal reliability of the items that measure

Table 2 - Description and statistics of the variable sustainability index.

	Description	*Mean*	*Standard deviation*	*Min.*	*Max.*
Return of Assets Y_{ROA}	Return of Asset. Takes the values: 1: lower than 5% 2: between 5% and 15% 3: between 15% and 25% 4: between 25% and 35% 5: higher than 35%	Portugal: 2.2 Spain: 2.09	Portugal: 1.08 Spain: 0.99	1	5
Carbon footprint $Y_{FOOTPRINT}$	The wineries scored their interest in adopting measures to reduce the carbon footprint on a scale of 1 to 5 where 1 was a low level of interest and 5 was a very high level of interest.	Portugal: 3.93 Spain: 3.78	Portugal: 0.94 Spain: 1.02	1	5
Corporate Responsibility Y_{CSR}	The wineries scored their interest in adopting sustainability measures concerning wages, gender, minorities and the community in which they operate on a scale of 1 to 5 where 1 was a low level of interest and 5 was a very high level of interest.	Portugal: 3.77 Spain: 3.55	Portugal: 0.95 Spain: 1.11	1	5
$Y_{SUSTAINABILITY}$	$Y_{ROA,\,i} + Y_{FOOTPRINT,\,i} + Y_{CSR,\,i}$	Portugal: 9.21 Spain: 8.70	Portugal: 2.95 Spain: 2.81	3	15
Cronbach's Alpha	Portugal: ζ=0.7938 Spain: ζ=0.8065				

$Y_{SUSTAINABILITY}$. For the index of Portugal, la scale reliability coefficient is ζ=0.7938 and for Spain it is ζ=0.8065. These values are acceptable, taking into account that the criterion established by different authors is that a ζ between 0.70 and 0.90 indicates good consistency (George and Mallery, 2003; Frías-Navarro, 2022; González and Pazmiño, 2015, Barrios and Cosculluela, 2013; Nunnally and Bernstein, 1994; Diedenhofen and Musch, 2016). Table 2 presents the descriptive statistics of the Sustainability index ($Y_{SUSTAINABILITY}$) of each of its items ($Y_{ROA,}$ $Y_{FOOTPRINT,}$ Y_{CSR}) and of the Cronbach's Alpha (ζ) for Spain and Portugal.

The variability of $Y_{SUSTAINABILITY,}$ indicates that the wineries have a different sensitivity when adopting policies to increase their sustainability. One reason for this could be the different geographical locations, either in Spain or in Portugal, and their different performance in response to climate change (Millán, 2021). The nonparametric Mann-Whitney U test, with value z = -2.265 and an associated probability lower than 0.05, Prob > |z|=0.0235, shows that Portugal and Spain have different behaviours in the variability of $Y_{SUSTAINABILITY}$. A non-parametric test has been used because the dependent variable $Y_{SUSTAINABILITY}$ does not follow a normal distribution according to the Shapiro-Wilk W test, with a W value of 0.95967 and an associated p-value lower than 0.05, p = 0.00000. The difference derived from the Mann-Whitney U test implies that it is necessary to consider a model for each country and identify the similarities and differences in sustainability, $Y_{SUSTAINABILITY}$, in relation to the independent variables that are presented in the following section.

4.1.2. *Independent variables*

As independent variables, in agreement with the research hypotheses, three blocks can be distinguished: a) planned investments, b) future challenges that are greater than those expected to be faced by the company and c) the level of interaction of the wineries with the different economic agents and d) special events in the period. Table 3 presents their description and statistical summary.

Table 3 - Description and statistics of the exogenous variables.

	Variables	*Description*	*Frequencies*	
		Discreet variables:	*Spain*	*Portugal*
Investments	Vineyard investment (VI)	Takes the value of 1 if the winery plans to invest in the vineyard and 0 otherwise.	F0: 358 F1: 59	F0: 102 F1:49
	Winery investment (WI)	Takes the value of 1 if the firm plans to invest in the winery and 0 otherwise.	F0: 349 F1:68	F0: 114 F1:37
	Investment in management, marketing and sales (MI).	Takes the value of 1 if the firm plans to invest in management and 0 otherwise.	F0: 265 F1:152	F0: 91 F1: 60
Challenges	Future commercial challenges (CC)	Takes the value of 1 if the firm expects to face commercial challenges and 0 otherwise.	F0: 319 F1:98	F0: 54 F1: 97
	Future financial challenges (FC)	Takes the value of 1 if the firm expects to face financial challenges and 0 otherwise.	F0: 389 F1:28	F0: 81 F1:70
	Future environmental challenges (EC)	Takes the value of 1 if the firm expects to face environmental challenges and 0 otherwise.	F0: 394 F1:23	F0: 64 F1:87
	Future challenge of increased competition (COC)	Takes the value of 1 if the firm expects to face challenges of increased competition and 0 otherwise.	F0: 374 F1:43	F0: 125 F1:26
	Future challenge of increased quality (QC)	Takes the value of 1 if the firm expects to face challenges arising from the need to increase quality and 0 otherwise.	F0: 260 F1:157	F0: 81 F1:70
Environment	Level of interaction of the winery with the public administration (LIPA)	Takes the value of 1: high level of interaction. Takes the value of 2: low level of interaction.	F0: 373 F1:44	F0: 146 F1:5
	Level of interaction of the winery Regulating Councils (LIRC)	Takes the value of 1: high level of interaction. Takes the value of 2: low level of interaction.	F0: 201 F1:216	F0: 103 F1:48
	Level of interaction of the winery with other wineries (LIW)	Takes the value of 1: high level of interaction. Takes the value of 2: low level of interaction.	F0: 269 F1:148	F0: 137 F1: 14
	Level of interaction of the winery with suppliers and clients (LISC)	Takes the value of 1: high level of interaction. Takes the value of 2: low level of interaction.	F0: 108 F1:309	F0: 74 F1:77
Special event in the period	Covid Impact (CI)	Takes the value of 1 if the winery considers that Covid has had an impact on its business and 0 otherwise.	F0: 164 F1:253	F0: 40 F1:111

4.2. *Econometric function*

In order to conduct the study, a left-hand-side Box-Cox model was used for two reasons. The first is that the dependent variable, $Y_{SUSTAINABILITY,}$ does not follow a normal distribution according to the Shapiro-Wilk W-test and the second is that all of the independent variables are discreet. Its analytical expression is as follows:

$$Y^{\theta}_{SUSTAINABILITY} = \sum_{k=0}^{13} \beta_k X_{ki} + u_i =$$

$$= \beta_0 + \beta_1 VI_i + \beta_2 WI_i + \beta_3 MI_i + \beta_4 CC_i + \beta_5 FC_i + \beta_6 EC_i + \beta_7 COC_i + \beta_8 QC_i + \beta_9 LIPA_i$$

$$+ \beta_{10} LIRC_i + \beta_{11} LIW_i + \beta_{12} LISC_i + \beta_{13} CI_i + u_i$$

with i= 1,..., 151, for the sub-model of Portugal; with i=152,..., 568 for the sub-model of Spain.

Table 4 - LR statistic for powers with theta values (-1, 0, 1).

	LR statistic Test h0	*Restricted log likelihood*	*LR statistic chi2*	*P-value Prob > chi2*
Portugal Model Model(lhsonly) left-hand-side Box-Cox model	theta = -1	-348.75387	66.94	0.000
	theta = 0	-323.17678	15.79	0.000
	theta = 1	-315.28355	0.00	0.969
Spain Model Model(lhsonly) left-hand-side Box-Cox model	theta = -1	-1223.9211	612.76	0.000
	theta = 0	-983.22209	131.36	0.000
	theta = 1	-919.0783	3.07	0.080

Table 5 - Theta powers estimated from the Box-Cox procedure.

	Power	*Coef. Std.*	*Std. Err.*	*z*	*P>z*
Portugal Model Model(lhsonly) left-hand-side Box-Cox model	theta	1.010338	0.2653291	3.81	0.000
Spain Model Model(lhsonly) left-hand-side Box-Cox model	theta	1.214357	0.1253277	9.69	0.000

θ is the Box-Cox power for transforming the dependent variable, $Y_{SUSTAINABILITY}$, β_k, with k= *0, 1,…11*, are the parameters to estimate, *VI* is the planned investment of the winery in the vineyard, *WI* is the planned investment in the winery, *MI* is the planned investment in management, marketing and sales, *CC* are the future commercial challenges, *FC* are the future financial challenges, *EC* are the future environmental challenges, *COC* is the future challenge of increased competition, *QC* is the future challenge of increasing quality, *LIPA* is the level of interaction of the winery with las public administrations, *LIRC* is the level of interaction of the winery with the regulatory councils of the designations of origin, *LIW* is the level of interaction of the winery with other wineries, *LISC* is the level of interaction of the winery with suppliers and clients, *CI* is the perceived impact of Covid-19 on the business, u_i is the random shock or statistical error.

The econometric software STATA 15 is used to obtain statistical and econometric results.

5. Results and discussion

First, the value of θ is identified with the Model(lhsonly), left-hand-side Box-Cox model, selecting for the power θ with a p-value higher than 0.05 for the LR test associated to θ, whose values can be -1, 0, 1 (Table 4), or lower than 0.05 for specific θ values (Table 5).

Table 6 - Theta powers estimated from the Box-Cox procedure.

	Possible Power	*Root MSE*
Portugal Model	θ = 1	2.2394
	θ = 1.010338	2.3153
Spain Model	θ = 1	2.3687
	θ = 1.214357	4.5369

The results indicate that both for the model for Portugal and that for Spain, there are two possible transformations, θ, for . The θ with a lower root mean square is selected (Root MSE). This is that of θ=1 for both countries (See Table 6).

To summarise the output provided by STATA, the following conventions have been used. First, statistical significance for all tests has been set at a p-value not exceeding 0.10. The results of this estimate, shown in Table 7, enable us to extract conclusions regarding the determinants of adopting policies to improve the sustainability of the wineries in Portugal and Spain and the results of their significance.

According to the Ramsey RESET test and specification link test for single-equation models (Hatsq), the estimated models are correctly specified. The F-Snedecor, with a p-value lower

Table 7 - Results of the estimation.

	Portugal Model	*Spain Model*
Vineyard investment (VI)	0,692171* (0,451112)	0,352949 (0,3694361)
Winery investment (WI)	-0,31618 (0,541971)	0,301122 (0,3664657)
Investment in management, marketing and sales (MI).	-0,51077 (0,446888)	0,452583* (0,2670338)
Future financial challenges (FC)	-0,10259 (0,432433)	-0,12324 (0,4928245)
Future commercial challenges (CC)	-0,27518 (0,47321)	0,221344 (0,2881805)
Future environmental challenges (EC)	0,284875 (0,408497)	1,853663*** (0,5212917)
Future challenge of increased competition (COC)	0,66126 (0,541306)	-0,43503 (0,3923265)
Future challenge of increased quality (QC)	0,73231** (0,392797)	0,12307 (0,249488)
Level of interaction with public administration (LIPA)	-0,28772 (1,106608)	0,198416 (0,3987458)
Level of interaction with Regulatory Councils (LIRC)	-0,3491 (0,426472)	0,356267* (0,2500997)
Level of interaction with other wineries (LIW)	0,132763 (0,683255)	0,536192** (0,2656126)
Level of interaction with suppliers and clients (LISC)	1,053437** (0,40326)	0,555775** (0,2983354)
Covid Impact (CI)	-0,29573 (0,440229)	0,044758 (0,2427928)
Constant	9,953423*** (0,641064)	7,759575*** (0,3248983)
Validation test of the models		
Ramsey RESET test	F(3, 128) = 0.42 Prob > F = 0.7371	F(3, 389) = 0.12 Prob > F = 0.9473
Hatsq	P>|t| = 0.830	P>|t| = 0.855
F-Snedecor	F(13, 131) = 1.84 Prob > F = 0.0430	F(13, 392) = 3.15 Prob > F = 0.0002
Mean VIF	1.27	1.14
Breusch-Pagan	chi2(1) = 0.05 Prob > chi2 = 0.8265	chi2(1) = 2.58 Prob > chi2 = 0.1084

*In brackets, the standard deviation of the coefficient estimates. * Denotes significance at the 10-percent level. ** Denotes significance at the 5-percent level. *** Denotes significance at the 1-percent level.*

than 0.05, shows the overall explanatory variable is globally significant, being models without multicollinearity, with a VIF of less than 10. On the other hand, the Breusch-Pagan test, with a p-value higher than 0.05 shows a constant variance. Below the individual significance of the variables in each model is explained.

For Portugal, the sustainability orientation can be observed to be positively related to investment in the vineyard (*VI*), the forecast of future challenges focused on the quality (*QC*) and interaction with suppliers and clients (*LISC*). Viticulture is one of the most important activities in the wine industry, due to the production

of grapes, and in Portugal it has a larger environmental impact (Neto *et al.*, 2013). Thus, investments in the vineyard can lead towards profitability improvement and the adoption of more sustainable practices that can increase product quality, valued throughout the wine value chain (Pinto *et al.*, 2022). These variables are strictly related to the concept of sustainable management in this sector, which is defined as "a long-term strategy connecting the environmental, heritage, cultural, economic and social components" (Rebelo, 2017). The positive effect found for VI corroborates the study of Swiatkiewicz (2021) that finds that Portuguese wine producers are following the trends in sustainable wine market management, with the renovation of viticulture being one way to do this. The quality related to environmental and health issues is becoming increasingly appreciated by consumers, which is supported by the findings of previous studies (Pinto *et al.*, 2022; Swiatkiewicz, 2021), particularly in a highly globalised winemaking sector, (OIV, 2023), which gives rise to strong international competition in terms of quality (Sotés Ruiz, 2018). Hypotheses 1 and 2 are fulfilled but only in one item of each.

For the Portuguese wineries, the interaction with the suppliers and clients (*LISC*) is focused on their interest in improving their environmental management (Chen, 2008; Annunziata *et al.*, 2018; Taylor, 2017; Marta-Costa *et al*., 2022). The relationship with the rest of the interest groups is not significant. One of the reasons for this is that the Portuguese suppliers cover this need by paying a tariff, so that public institutions, associations and producer associations, distributors, cooperatives and distilleries can promote Portuguese wine (Swiatkiewicz, 2021). Therefore, Hypothesis 3 is partially confirmed. Finally, Hypothesis 4 is not confirmed, given the non-significance of the Covid-19 health crisis for Portugal. One of the reasons, as indicated in Niklas *et al.* (2022), is that the business models of the Old World wines have been more resistant to the impacts of Covid-19 and this, according to Arora (2020), has not affected the sustainability orientation. The wine industry as a whole has proved to be more resistant than other sectors, largely due to the capacity to adopt innovative and technological solutions to restrictive measures, such as e-commerce (Francás, 2022).

The Spain model indicates that investment in management, marketing and sales (*MI*), the environmental challenges (*EC*) and the level of interaction with the Regulatory Councils (*LIRC*), with other wineries (*LIW*) and with suppliers and clients (*LISC*) influence the sustainability of the wineries. With regard to the investment in management, marketing and sales (*MI*), the relationship is positive and significant. The same result has been obtained by different authors and is based on the need for the consumer to be aware of the effort that the winery makes to produce a differentiated, sustainable and eco-friendly product (Sellers and Nicolau, 2016; Flores, 2018; Moscovici and Reed, 2018, García-Cortijo *et al*., 2021). Therefore, for Spain, Hypothesis 1 is fulfilled for the *MI* variable. On the other hand, the Spanish wineries that are most sensitive to sustainability are those that contemplate environmental challenges (*EC*) in their future scenario, due to the pressure of consumers and citizens (Bordeaux Sciences Agro, 2022). Therefore, Hypothesis 2 is fulfilled only with the variable *EC*. Spanish wineries show a high level of interaction with the Regulatory Councils (*LIRC*), with other wineries (*LIW*) and with suppliers and clients (*LISC*). As indicated by Barco (2015), the dispositions in the sector cannot be separated from the social and economic interests existing in it and determine, at all times, the actions of the productive forces or economic agents and interprofessional relations and the perception of the producer as an environmental administrator (Bisson *et al*., 2002). The intensity of these relations can motivate and facilitate sustainability orientation and improve their competitive advantage (Chen, 2008). Hypothesis 3 is confirmed. Finally, Hypothesis 3 is not fulfilled because the variable (CI) is not significant and Covid-19 does not have an impact on the winemaking industry, as established by Niklas *et al*. (2022) and contrary to that indicated by Witter and Anderson (2021).

Portugal and Spain are traditional wine pro-

ducers that share a spatial unit but differ in the way they approach sustainability. The Portuguese wineries opt for structural and traditional measures based on the management of the vineyard and the quality of the wine (Malheiro *et al*., 2010; Santos *et al.*, 2018; Sotés Ruiz, 2018), determined by a scenario of a reduction in the vineyard area, 31% since 1989 and 15% over the last five years, and on the quality wine option which continues to gain ground, accounting for 82% of national production (Barros, 2018). In addition, 50% of output is produced by small and medium-sized farmers associated with cooperatives (Rebelo & Caldas, 2015), mostly men with a very low educational level and of an older age (Figueiredo & Franco, 2018; Rebelo & Caldas, 2015) and cooperatives that are highly resistant to change (Figueiredo & Franco, 2018).

On the other hand, Spain prefers more short-term measures aimed at promoting the field of organisation, marketing and sales, taking environmental issues into account. One of the reasons is that Spain is one of the world's leading exporters (OIV, 2023) and the international market has demonstrated a high level of sensitivity to sustainable wine (Santini *et al*., 2013; Flores, 2018; Moscovici and Reed, 2018; Stasi *et al*., 2016, Gabzdylova *et al*., 2009; Corbo *et al*., 2014; Barbosa *et al*., 2018; Schäufele and Hamm, 2017), which would constitute a considerable advantage (Atance Muñiz, 2018; Menna & Walsh, 2019). Therefore, its wineries are committed to developing marketing and advertising policies so as to keep their consumers stimulated (Ramos, 2018) and to communicate the characteristics of the differentiated product (Sogari *et al.*, 2017; Sellers and Nicolau, 2016, Flores, 2018; Merli *et al.*, 2018; Szolnoki, 2013; Ferrer *et al.*, 2022). With respect to the level of interaction with the interest groups, Portugal focuses on suppliers and clients while Spain is more open to Regulatory Councils and other wineries. One of the reasons for this difference is that in Portugal awareness raising programmes are required in order to increase the sensitivity of the consumers, winemakers and oenologists (Santos *et al.*, 2018; Swiatkiewicz, 2021).

6. Conclusion

Portugal and Spain form a group of traditional producers with an experienced market and an awareness about climate change. In this study, we have sought to identify the principal determinants of interest in practices that improve the sustainability of wineries in Portugal and Spain. Our results highlight that the wineries are highly concerned about sustainability, but their behaviour is different depending on the territory in which they are located. Investments to ensure growth, the anticipation of future challenges and the environment influence their sustainability policies, but in different ways.

The wineries in Portugal and Spain are oriented towards sustainability, but the measures and actions that they adopt are directly related to the idiosyncrasy of their origin. Portugal is conditioned by the continuous reduction of the vineyard area, by the national market, which prefers quality wine and by producers who are resistant to change. Spain is committed to the international market, seeking the continuous support of the interest groups. Therefore, sharing a territorial space is not synonymous for a common standard approach towards sustainability. The unique characteristics of an area determine its actions. In this respect, homogeneous policies in unequal territories are not effective; the European guidelines in the winemaking sector to make the most if its potential cannot overlook the individual features of each state.

This research is limited by the design of the sample. Prior to the random sample, a stratified sample would be advisable in order to separate the population into homogeneous segments so as to then apply a random sample to each strata. Furthermore, the study is limited to Portugal and Spain, so it would be desirable to extend the study to other countries such as France and Italy in order to draw more precise conclusions regarding territorial sustainable policies.

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