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The agroecological challenges in the wine sector: perceptions from European stakeholders

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Abstract. This article explores the issues surrounding the agroecological transition in the European wine industry, focusing on reducing pesticide use, developing organic certification and using genetic research in relation to resistant grape varieties. The study distinguishes between stakeholders from the wine industry, institutions and the agricultural research sector. The findings consistently identify the agroecological transition as a priority, particularly in terms of pesticide reduction. However, variations exist in the views of the surveyed stakeholders. French and Portuguese stakeholders emphasise the role of market and societal pressures as drivers of the transition, while Italian producers do not. Professionals in France and Portugal express doubts about achieving pesticide reduction through changes in practices, while others stress the importance of regulatory constraints. The research also highlights industry challenges such as decreased consumption due to health awareness and the need for social responsibility. Resistant grape varieties are seen as a viable solution, especially for the development of organic production, but market acceptability remains a significant hurdle. The study sheds light on stakeholder perspectives and challenges, thus contributing to a better understanding of priorities in the European wine industry's pursuit of sustainable practices.

Keywords: wine economics, wine sustainable innovations, stakeholders' perceptions, agroecological transition, organic certification, resistant varieties.

1. INTRODUCTION

The agroecological transition has become a significant issue in European vineyards due to the extensive use of pesticides in the wine industry. However, the sector is also facing challenges concerning its carbon footprint, even though it contributes a relatively small percentage to agricultural greenhouse gas emissions. Viticulture frequently experiences the negative effects of climate change, such as irrigation difficulties, vine diseases and the inadequacy of traditional grape varieties, resulting in a loss of wine character [1,2]. In addition to environmental challenges, the wine industry is confronting various obstacles, including a decline in consumption in traditionally wine-drinking countries. This decrease can be attributed, at least in part, to increasing health consciousness among consumers, influenced by health lobbies. The sector's social responsibility and the economic organisation of fragmented industries also play a role, particularly when the absence of large trading companies hinders commercialisation efforts [3].

Given the multitude of challenges at hand, it is not surprising that stakeholders may not be fully convinced to prioritise the agroecological transition. While some progress has been made, a major revolution has yet to emerge to address these concerns. This article aims to shed light on the issues that stakeholders perceive as priorities, taking into account the perspectives of professionals in the wine industry, institutions and the agricultural research sector, who provide alternative viewpoints.

The policy environment in the EU pushes for a significant reduction of the environmental impact of production activities across the EU. In particular, the new common agricultural policy (CAP), which entered into force in January 2023, pledges to target more ambitious environmental and climate-related commitments than its predecessors. Considering the wine sector, it is explicitly recognised that 'while the successive 2008 and 2013 reforms of the wine policy have overall achieved their objectives, resulting in an economically vibrant wine sector, new economic, environmental and climatic challenges have appeared'[1] [4].

These more ambitious commitments were quantified in the farm-to-fork strategy, released by the Commission in 2020, while the reform process was slowly proceeding. The document announced that the Commission itself was to take additional action to reduce the overall use and risk of chemical pesticides by 50 % and the use of more hazardous pesticides by 50 % by 2030, without compromising farmers' incomes. Furthermore, it stated that EU Member States should consider such a target in the design of the Strategic Plan, the new CAP programming tool introduced by Regulation (EU) 2021/2115 (Strategic Plan Regulation)[2] [5].

The strategic plan regulation is not highly prescriptive concerning the financial resources allocated to addressing environmental issues in the wine sector. It only mandates the allocation of at least 5 % of the budget for actions that have a positive impact on the environment, climate change or sectoral sustainability [6]. Beyond these financial constraints, sectoral interventions provided for in the strategic plan regulation include a variety of intervention types that may support the agroecological transition of the vitivinicultural sector. This transition could also be supported by resources derived from the renewed mechanisms for calculating CAP direct payments, particularly from the new voluntary environmentally friendly practices (ecoschemes) and from the rural development policy [5,6].

The options provided by the CAP spending measures available to vine growers could contribute to improving the environmental performance of the EU wine sector. However, given the current state of vineyard protection techniques, such improvement would seem largely insufficient to achieve the target of halving pesticide use by 2023.

The CAP reform, through Regulation (EU) 2021/2117 (amendment regulation)[3], allows the inclusion of varieties derived from a cross between *Vitis vinifera* and other species of the genus *Vitis* in the production of wine with a protected designation of origin (PDO). These vine varieties are better adapted to changing climatic conditions and exhibit greater resistance or tolerance to diseases, enabling a significant reduction in the number of required treatments (usually to only three or four). Indeed, after lifting the ban on their use in PDO wine production, these varieties may

[1] Explanatory memorandum to reform proposals (p. 14).

[2] Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP strategic plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013 (OJ L 435, 6.12.2021, p. 1).

[3] Regulation (EU) 2021/2117 of the European Parliament and of the Council of 2 December 2021 amending Regulations (EU) No 1308/2013 establishing a common organisation of the markets in agricultural products, (EU) No 1151/2012 on quality schemes for agricultural products and foodstuffs, (EU) No 251/2014 on the definition, description, presentation, labelling and the protection of geographical indications of aromatised wine products and (EU) No 228/2013 laying down specific measures for agriculture in the outermost regions of the Union (OJ L 435, 6.12.2021, p. 262).

attract greater interest and could be a game changer for the future of sustainable winemaking, helping to align the industry with the aims of the Farm to Fork Strategy [7,8].

Previous research has highlighted that the cultivation of wine grapes and the production of wine are associated with a myriad of environmental issues. These concerns primarily revolve around the use of chemicals, particularly pesticides [5]. This concern regarding pesticides has been associated with consumers paying increasing attention to environmental protection and sustainable development, creating new awareness and opportunities [10]. However, differing views on how best to address this issue within the sector could potentially confuse consumers and delay the implementation of adaptation measures [11-16].

This study investigates this issue by analysing stakeholder perceptions of the ongoing agroecological transition, focusing particularly on the use of pesticides in the wine sector and potential strategies to address the problem. The research centres on two distinct strategies: organic production and the use of resistant grape varieties. To this end, a questionnaire was sent to the main stakeholders in the wine sectors of three major wine-producing countries, namely France, Italy and Portugal. Participants were asked about the significance of environmental issues for their businesses. This study aims to highlight stakeholder beliefs about sustainable innovation in the wine industry, addressing the following research questions. What influences stakeholder perceptions of an agroecological transition in the wine sector? Which strategy do wine sector stakeholders consider most viable in the long term? What is the role of resistant grape varieties?

The article is structured as follows. The subsequent section presents the survey and the methods for its analysis. This is followed by the results, which are divided into two parts: the components of perceptions and the multivariate analysis. A comparison of organic certification versus resistant varieties is then discussed, and the article finishes with the primary conclusions and policy implications.

2. METHODOLOGY AND DATA SOURCE

In 2018–2019, the questionnaires were sent to 1 525 randomly selected stakeholders in three countries, namely France, Italy and Portugal. Stakeholders were selected from lists of addresses from the European territorial cooperation programme Interreg VB southwest Europe. They included professionals, representatives of institutions and representatives from the research sector, while consumers and citizens were not targeted. Before the questionnaire was emailed to stakeholders, it was pretested in a short survey involving some representative stakeholders. After the pretest sessions, questions were improved based on the stakeholders' suggestions and comments. After screening for completeness, 877 questionnaires were retained for this analysis.

The survey questionnaire consisted of three parts, that is, questions related to (i) the importance stakeholders accorded to environmental issues, among other issues, in particular the challenges the wine sector will face, (ii) the levers identified by the stakeholders that could make the agroecological transition possible and (iii) the stakeholders' perceptions of innovations related to organic certification and resistant grape varieties. All were closed questions, and responses were collected on a Likert scale varying from 1 (strongly disagree) to 5 (strongly agree) [17]. In total, the questionnaire included 68 variables.

The 12 questions from part II of the questionnaire were used to create the dependent variables, representing the stakeholders' perceptions of the agroecological transition in the wine sector. Parts I and III were included in the models as explanatory characteristics, in order to capture the importance attributed to the environmental issues and the future challenges of the sector (part I) and how stakeholders' perceive the innovations regarding organic certification and resistance varieties (part III). Information about sociodemographic characteristics was also included in the questionnaires and divided into categories of responses, which are presented in Table 1. The information covers the country (three countries), gender (woman, man, n/a (preferred not to respond)) and age of participants (five categories of age); the sector of the institution that the respondent represents and the size of the institution (in number of employees, with four possible categories). The size of institution was not included in the analysis, since comparing the sizes of diverse groups of stakeholders was considered meaningless to this analysis. The stakeholders' sectors were grouped into six categories: public administration (excluding research); associations (e.g. syndicates, interprofession associations, farmers associations, commissions of viticulture); producers (e.g. cooperative members or managers, independent farmers, large private production/commercialisation companies); suppliers (e.g. companies supplying inputs, for example nurseries, oenological equipment, bottles, corks); research institutes; and others (e.g. those currently linked to professional wine activity, for example sommeliers and consultants).

Table 1. Frequency table of sociodemographic variables' categories.

Variable	Categorization	Frequency	%
Country	Italy	489	55.8
	Portugal	122	13.9
	France	266	30.3
Age (12 missing)	Less than 24 years old	36	4.1
	From 25 to 34 years old	184	21
	From 35 to 49 years old	279	31.8
	From 50 to 64 years old	289	33
	More than 65 years old	65	7.4
Sector (12 missing)	Public administration	67	7.6
	Associations	57	6.5
	Producers	389	44.4
	Suppliers	80	9.1
	Research institutes	124	14.1
	Others	148	17
Gender	Women	213	24.3
	Otherwise	664	75.7
Size (14 missing)	Less than 50 employees	451	51.4
	Between 50 and 250 employees	160	18.2
	More than 250 employees	172	19.6
	Currently without professional activity	80	9.1

The table shows that the largest share of complete responses was from Italy. Most of the respondents were between 35 and 64 years old, while 25.1 % were younger than 34 years old; 24.3 % of the total were women. Producers represent the main category among the sectors, followed by the 'others' group and the representatives of research institutes.

Before the regressions were carried out, the number of variables was reduced by principal component analyses (PCAs): for perceptions related to the agroecological transition, for perceptions related to organic certifications and for perceptions related to resistant grape varieties. The relationships among these perceptions were studied by means of multivariate regressions [18]. Standard parametric statistical procedures were used for the PCA of ordinal Likert scale variables [19].

The conduct of the multivariate analysis followed the steps described by Hair et al., Meuwissen et al. and Alvarez et al. [18,20,21]. The variables selected were submitted to the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity [18]. Only variables that presented an individual KMO of ≥ 0.5 were maintained for analysis [18]. The suitability of the analysis was confirmed by applying Bartlett's test, which presented $p = 0.000$ for all subsamples, confirming that the dataset was suitable for PCA. The number of factors retained in the PCA was based on the Kaiser criterion (i.e. eigenvalues of > 1) and a varimax orthogonal rotation was implemented in all subsets of components [18].

Subsequently, we used multiple regression to assess the relationships between the perceptions of agroecological transitions (components y1–y4), perceptions of environmental issues and challenges for the sector (components a1–a6), organic labels (components b1–b4), resistance varieties (components c1 and c2) and sociodemographic variables. In the regression analyses, multicollinearity between the independent variables was not present and no variables were omitted. A correlation test showed that, for all other socioeconomic variables, the correlations were low and variation inflation factors were all around 1 [18].

3. RESULTS OF THE COMPONENT OF PERCEPTION

3.1 Perceptions of agroecological transition

Twelve statements were used to gather insights into perceptions related to the levers that can make the agroecological transition possible, as shown in Table 2.

These were reduced to only four components with eigenvalues larger than 1 using PCA, accounting for 58 % of the total variance. According to the component loadings, components 1–4 can be best described as:

- **y1, technology and financial incentives.** This component is mainly characterised by having the highest values in variables 3, 5 and 9, which relate the agroecological transition to increased technological innovations and financial incentives that will grant farmers' access to these technologies. The incentives can also be in the form of agri-environmental aids.
- **y2, producers' information and awareness.** The second component is represented by variables 4, 8 and 10, which are related to producers having increased information and awareness, which could lead to changes in their production practices. In particular, production practices concerning reduced pesticide use at the individual level that drive the agroecological transition.
- **y3, societal and consumer pressure.** The third component is mainly formed by variables 1 and 2, meaning that the agroecological transition will be possible because of increased demands from consumers and society.
- **y4, regulations and standards.** The last component is primarily characterised by variables 11 and 12 and, to a lesser extent, variable 7. These refer to strengthening environmental legislation and public control over producers in a top-down approach, pushing producers in the direction of the agroeco-

Table 2. Statements on the stakeholders' perceptions about agroecological transition (Part "B" of the questionnaire) and rate of responses.

The agroecological transition will be possible …	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1. In view of the increasing demands of consumers	14.8 %	51.2 %	23.9 %	8.3 %	1.7 %
2. In view of the increasing demands of society	13.1 %	48.8 %	28.5 %	8.1 %	1.5 %
3. If technological innovations develop sufficiently	26.8 %	54.5 %	14.5 %	3.6 %	0.6 %
4. If we have an increase in winegrowers' awareness, leading to substantial changes in their agricultural practices	35.2 %	52.0 %	8.1 %	4.2 %	0.5 %
5. If we have better financial incentive systems to remunerate the individual efforts of producers (agri-environmental aid)	29.6 %	46.2 %	15.6 %	6.4 %	2.2 %
6. If we have a crop insurance development	13.3 %	39.7 %	31.9 %	11.6 %	3.4 %
7. If there is a development of private market downstream standards (specifications for private labels, standardisation requirements, importers' standards, requirements of intermediaries, etc.)	9.6 %	38.1 %	30.2 %	17.0 %	5.1 %
8. If we have better communication between the wine world and society (organisation of places of exchange)	23.1 %	53.5 %	18.1 %	4.6 %	0.7 %
9. If we have increased subsidies for the acquisition of more efficient equipment (promoting precision viticulture, new plant material, etc.)	29.6 %	45.0 %	16.4 %	6.8 %	2.1 %
10. If we have more information resources for winegrowers to better understand the possibilities of reducing pesticides at the individual level	37.9 %	48.1 %	9.8 %	3.6 %	0.6 %
11. If we have a strengthening of environmental regulations	16.1 %	47.7 %	22.8 %	10.5 %	3.0 %
12. If we have a strengthening of the effectiveness of controls by the public sector	14.9 %	34.2 %	28.7 %	17.6 %	4.6 %

logical transition. Beyond public regulations, private standards and labels with specific rules and requirements can also lead to the transition.

An overall KMO value of 0.76 was recorded. These four components can be understood as **how stakeholders perceive the agroecological transition**. They served as the dependent variables in the regression models.

3.2 Perceptions of environmental issues and challenges for the sector

Twenty two statements were used to gather insights into perceptions related to the importance stakeholders accorded to environmental issues, in particular the sustainability challenges the wine sector will face (Table 3).

These were reduced to only six components with eigenvalues greater than 1 using PCA, accounting for 53 % of the total variance. An overall KMO value of 0.82 was recorded. According to the component loadings, components 1–6 can be best described as follows.

- **a1, territory and culture.** Variables 8 and 19 characterise this component. According to these variables, the main sustainability challenges that the sector will face are related to strengthening the cultural character of the wines and the territorial heritage linked to the viticulture and preserving the landscapes attached to the wines.
- **a2, reducing chemicals.** This component is mainly formed by strong agreements in variables 4, 7 and 16. These are related to the reduction of pesticides and chemicals in the production and processing of wines in order to meet societal expectations in this regard, moving in the direction of producing more 'nature' wines. Furthermore, the specifications of PDOs and IGPs should be reoriented in the direction of sustainable production.
- **a3, consumers' and retailers' needs.** This component is formed of variables 9, 17 and 20. It groups the strong agreements on the main sustainability challenges linked to adapting the sector to the changing tastes and uses of consumers and consequently to the downstream requirements. There will also be challenges related to increasing the size of farms to promote the creation of new independent brands (commercialising more final products).
- **a4, European regulation.** This component represents variables 13–15, which refer to the stricter upcoming European regulations and the challenges the sector will face in adapting to them. Challenges are more severe production conditions at the vineyard level, and the consequent additional costs, and changes to labelling.
- **a5, decline of vineyards and yields.** This component is formed of only variable 3. This question

Table 3. Statements on the stakeholders' perceptions of the importance accorded to environmental issues, among other issues (part I of the questionnaire), and response rates

In your opinion, what are the sustainability challenges that the wine sector will face in your country regarding…	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1. Adapting to climate change	50 %	41 %	6 %	2 %	1 %
2. Showing that drinking wine in a moderate way is not incompatible with health	45 %	37 %	12 %	5 %	1 %
3. Adapting to the decline of the vineyard and the risk of reduced yields	18 %	37 %	18 %	17 %	9 %
4. Meeting societal expectations for reducing pesticides	47 %	41 %	8 %	4 %	1 %
5. Reducing the carbon footprint	33 %	44 %	19 %	3 %	1 %
6. Adapting alcohol content to public health policies	5 %	24 %	32 %	27 %	12 %
7. Reducing the use of oenological inputs (SO_2, ...) and go in the direction of more 'Natural' wines	16 %	34 %	26 %	16 %	7 %
8. Strengthening the cultural character of wine and the territorial heritage linked to viticulture	48 %	40 %	9 %	3 %	1 %
9. Adapting to changing tastes and uses of consumers (on the national and international market)	19 %	46 %	21 %	10 %	3 %
10. Facing international competition	26 %	41 %	17 %	12 %	4 %
11. Optimising the functioning of sector organisations	26 %	54 %	16 %	4 %	1 %
12. Improving business-to-business relationships from upstream to downstream in the sector	25 %	52 %	19 %	4 %	1 %
13. Adapting to changes in European regulations on production conditions at vineyard level	10 %	43 %	28 %	14 %	5 %
14. Adapting to the additional costs that will result from changes in European regulations	8 %	33 %	30 %	22 %	7 %
15. Adapting to changes in European wine labelling regulations	10 %	40 %	30 %	15 %	5 %
16. Reorienting the specifications of PDO-IGP in the direction of sustainable development	32 %	48 %	13 %	5 %	1 %
17. Adapting to changing requirements downstream of the sector (mass distribution, importers, trading)	8 %	28 %	29 %	26 %	9 %
18. Responding to corporate social responsibility (improvement of working conditions, remuneration, etc.)	34 %	48 %	16 %	3 %	0 %
19. Preserving the vine and wine landscapes	56 %	35 %	8 %	2 %	0 %
20. Increasing the surface areas of farms to promote the creation of corporate brands	4 %	10 %	27 %	37 %	22 %
21. Simplifying wine labelling and quality signs	24 %	39 %	21 %	11 %	4 %
22. Developing investments in insufficiently explored production areas (in your country or abroad)	11 %	31 %	29 %	22 %	8 %

refers to challenges that sustainability will bring in terms of adaptation to the decline of the vineyard and the risk of reduced yields.

– **a6, new production areas.** This component represents variable 20, but mostly variable 22. It is linked to the challenges and investments necessary for exploring new production areas and expanding the vineyards into other regions. It also concerns increasing farms' surface areas to promote the creation of own company brands.

3.3 Perceptions of organic certification

Eighteen statements were used to gather insights into stakeholders' perceptions of innovations related to organic certification (Table 4).

These were reduced to only four components with eigenvalues larger than 1 using PCA, accounting for 48 % of the total variance. According to the component loadings (Tables A1–A4 in the supplementary material), components 1–4 can be best described as follows.

– **b1, BIO not suitable for wine.** The first component groups variables 2 and 7 with a negative sign and variables 14–16. These can be translated into a component expressing the perception that wine is incompatible with organic production. There is a high level of agreement that organic production does not have the technical and economic capacities necessary for it to develop in many wine regions of the country and it is more relevant for other agricultural productions. There was agreement that organic certification cannot establish itself as the environmental benchmark and that

Table 4. Statements on the stakeholders' perceptions of focusing on organic certification (part III of the questionnaire) and response rates.

About organic farming …	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1. BIO is the most well-known certification logo among wine consumers for pesticide reduction	25 %	48 %	16 %	8 %	3 %
2. Organic production has the technical and economic capacities to develop significantly in many wine regions of our country	12 %	44 %	25 %	16 %	4 %
3. Adopting organic certification is too expensive	8 %	25 %	42 %	19 %	6 %
4. Organic certification risks being exceeded by certification types such as 'biodynamic' or 'natural' wine'	6 %	22 %	25 %	31 %	17 %
5. Organic certification concerns all types of wines in the quality and price scale	10 %	26 %	17 %	31 %	16 %
6. The repeated use of copper is a real problem for the societal credibility of organic certification	27 %	33 %	21 %	14 %	5 %
7. Organic certification will become the environmental standard	7 %	31 %	29 %	24 %	9 %
8. In the medium term there will be a deficit in the supply of organic wines	5 %	23 %	38 %	27 %	7 %
9. The organic production method is hardly compatible with climate change	8 %	18 %	23 %	37 %	14 %
10. The return risks linked to the organic production method are only bearable by companies that are already well established in the markets	10 %	33 %	24 %	25 %	7 %
11. Less demanding certification alternatives such as integrated production will eventually prevail on the market	9 %	30 %	30 %	22 %	9 %
12. More general certifications for the company (e.g. HVE, ISO standards) will become widely distributed	7 %	33 %	37 %	18 %	5 %
13. The organic production method can only develop on a large scale through significant public subsidies	9 %	22 %	27 %	29 %	13 %
14. The organic production method is less relevant for wine than for other agricultural productions	8 %	21 %	23 %	30 %	17 %
15. Organic wine is a fad that will eventually run out of steam	8 %	14 %	24 %	34 %	20 %
16. Organic wine can hardly be of good quality	3 %	7 %	20 %	34 %	36 %
17. The evolution of the regulations in organic production mode will make it impossible to produce these wines in certain regions	11 %	31 %	32 %	20 %	6 %
18. The BIO logo for wine is a detrimental addition to the proliferation of claims and certifications	9 %	23 %	28 %	30 %	10 %

NB: HVE, high environmental value (*haute valeur environnementale*); ISO, International Organization for Standardization.

organic wine is rarely good quality and will eventually run out of steam.

- **b2, BIO challenges to grow.** This covers variables 7, 10, 13 and 17 and represents the perception that, while organic certification has the potential to establish itself as the environmental standard, it can only develop on a large scale through significant public subsidies. According to this perception, the evolution of stricter regulations will make it impossible to produce wines in certain regions and the high risks linked to organic production will only be bearable for companies already well established in the market.
- **b3, BIO is a widespread label with competitors.** This component represents high levels of agreements on variables 1, 5, 6 and 12. These refer to the organic label not being limited to specific types of wine, but concerning all types of wine on the quality and price scales, and the BIO logo being the most well-known certification among wine consumers for pesticide reduction. However, other more general environmental/sustainability certifications, such as high environmental value (*haute valeur environnementale* (HVE)) (in France) and ISO, may become more widely distributed. In addition, the repeated use of copper can be a serious problem for organic certification's societal credibility.
- **b4, BIO alternatives.** This component groups high rates on variables 3, 4 and 18. Its most influential variable represents the perception that other certifications, such as 'biodynamic' or 'natural' wines, risk replacing organic certifications. This is especially the case because adopting organic certifications is too expensive and the BIO logo for wines is a detrimental addition to the proliferation of claims and certifications.

An overall KMO value of 0.88 was recorded. All components in this section include a certain degree of criticism of the organic certification, with none reaching unanimity that organic certification is the only viable solution for sustainable production of wine. Although component b2 groups the stakeholders' perceptions that best identify organic production as a viable strategy in the long run to reduce pesticides in wine production, despite challenges for expansion.

3.4 Perceptions of resistant grape varieties

Eleven statements were used to gather insights into the stakeholders' perceptions of innovations related to resistant grape varieties (RV) (Table 5).

These were reduced to only two components with eigenvalues greater than 1 using PCA, accounting for 50 % of the total variance. According to the component loadings, components 1 and 2 can be best described as follows.

- **c1, RV low reputation and acceptability.** This component covers variables 2, 3, 5 and 9, which are about criticism and low consumer acceptability of the use of resistant grape varieties in wine production. Concerns are related to the risks to the qualitative reputation of wines and that these will probably be assimilated to genetically modified organisms by consumers.
- **c2, RV driver of pesticide reduction.** This component groups variables 1, 8 and 10, which represent perceptions of good acceptability by consumers and a real solution regarding achieving significant reduction in the use of pesticides and the future of organic certification.

An overall KMO value of 0.88 was recorded. Component c2 groups the stakeholders' perceptions that identify resistant varieties of *Vitis* as a viable strategy to reduce pesticides in wine production in the long run and as the best solution for the future of organic certification.

4. RESULTS OF THE MULTIVARIATE REGRESSIONS

This section presents and discusses the results of the multivariate regressions on perceptions of the agroecological transition. For each dependent variable described in Section 3.1, Table 6 shows the partial regression coefficients. A full table of coefficients for the interactions of variables is shown in supplementary material Table A5. Overall, the factorial analysis detailed in the previous section detected four main perception types for the agroecological transition in the wine sector. These are

Table 5. Statements on the stakeholders' perceptions of focusing on resistant grape varieties (part III of the questionnaire) and response rates.

About varietal innovations …	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1. Resistant grape varieties are a credible solution to achieve a significant reduction in pesticide use	25 %	47 %	16 %	10 %	3 %
2. Resistant grape varieties run too great a risk to the qualitative reputation of mid-range wines	4 %	18 %	30 %	34 %	14 %
3. Resistant grape varieties run too great a risk to the qualitative reputation of wines with high added value	11 %	25 %	25 %	27 %	13 %
4. The bypassing of resistance, or the appearance of new diseases, will happen faster than the massive adoption of these grape varieties by winegrowers	7 %	28 %	43 %	17 %	5 %
5. In general, consumers will find it difficult to accept wines made from resistant grape varieties	4 %	20 %	30 %	34 %	12 %
6. Resistant grape varieties are an old illusory solution which has already proved its inability to satisfy professionals in the sector and /or the markets	3 %	12 %	34 %	35 %	17 %
7. Resistant grape varieties will only establish themselves in wine-growing areas with low awareness	4 %	19 %	29 %	35 %	13 %
8. The resistant varietal solution is the future of organic certification	8 %	33 %	34 %	19 %	6 %
9. Resistant grape varieties will be assimilated to GMOs by consumers	6 %	27 %	24 %	29 %	13 %
10. In general, producers will have no trouble accepting resistant grape varieties	6 %	38 %	25 %	25 %	6 %
11. We will probably have blockages on the part of producer groups, or institutions for the development of resistant grape varieties	9 %	37 %	30 %	20 %	4 %

NB: GMO, genetically modified organism.

Table 6. Results of multivariate regressions for perceptions of the agroecological transition.

Component code	Component name	y1, Innovation and financial incentives	y2, producers' information and awareness	y3, societal and consumer pressure	y4, regulations and standards
a1	Territory and culture	0.17***	0.21***	0.03	– 0.06*
a2	Reducing chemicals	0.06	0.26***	0.26***	0.30***
a3	Consumers' and retailers' needs	0.08*	– 0.03	0.14***	0.01
a4	European regulation	0.03	– 0.00	0.08*	0.12***
a5	Decline of vineyards and yields	0.04	0.04	– 0.02	– 0.03
a6	New production areas	0.17***	0.11***	– 0.02	0.10**
b1	BIO not suitable for wine	– 0.09***	– 0.07**	– 0.10***	– 0.13***
b2	BIO challenges to grow	0.27***	0.03	0.05	0.01
b3	BIO is a widespread label with competitors	– 0.07	0.02	0.05	0.06
b4	BIO alternatives	0.09*	0.11***	0.05	0.07
c1	RV low reputation and acceptability	0.01	0.03	– 0.03	0.06*
c2	RV driver of pesticide reduction	0.03	0.01	0.02	0.09**
	Country	– 0.10	– 0.05	0.18***	– 0.29***
	Age	– 0.06	0.03	0.06	– 0.09**
	Gender (1 = women)	0.05	0.16	– 0.05	0.06
	Sector	– 0.01	0.01	– 0.04*	0.04*
	Constant	0.45*	– 0.07	– 0.28	0.59***
	R^2	0.263	0.280	0.243	0.284
	DF	848	848	848	848

NB: DF, degrees of freedom. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

not entirely separate, as they may use similar composing variables in different orders, but, overall, they represent considerably different views of the transition which are supported by different socioeconomic groups.

These perceptions are best described in the four following subsections.

4.1 Innovation and financial incentives

Stakeholders who think that the agroecological transition will be possible with the development of further technological innovations and higher financial incentives (model 1), perceive the main challenges to be linked to the preservation of landscapes, cultural character and the territorial heritage of wines. Further challenges are associated with investments in new production areas and increases in the surface areas of farms. They also see difficulties in achieving large-scale organic production without support. Model 1 is the only model where variable **b2** is positive and significant, which shows that organic production is a viable strategy to reduce pesticides in wine production in the long run, but there are critical challenges to be overcome. According to model 1, those challenges can be confronted by providing farmers with better access to technology, innovations and financial incentives in order to enable the agroecological transition. No overall gender or age difference is present, but Italians most commonly share these perceptions. The interactions reveal that, in particular, those perceiving the agroecological transition in this way are mostly Italian women in mid-age ranges (25–49 years old) ([4]). The interactions between country and sector reveal that those in the 'others' group of stakeholders in France generally do not have these perceptions.

4.2 Producers' information and awareness

Stakeholders who believe that the agroecological transition will be possible with producers' improved access to information and awareness (model 2) on how to change their production practices believe that the main challenges are related to the preservation of landscapes, cultural character and the territorial heritage of wines. Another main challenge is related to improved information on how to reduce the use of chemicals in both the production and the processing of wines. The

[4] The estimation of all marginal effects for the four models can be provided upon request.

expansion of vineyards to new production areas will be a further issue to confront, and they perceive the BIO label/certification as expensive, which risks becoming outdated and surpassed by other labels, such as biodynamic and natural wines. In general, people aged 65+ and women have these perceptions. More specifically and according to the interactions, this applies to Italians aged 25–34 and 65+, Italian women, and respondents aged 65+ who are not women. These perceptions are not supported by French 25- to 34-year-olds. Interactions between country and sector show that French producers do not support these perceptions.

4.3 Societal and consumer pressures and market

Stakeholders who consider that the agroecological transition will be achieved through societal and consumer pressure (model 3) consequently also identify that the main challenges lie in the adaptation of the sector to meet consumer and retailer needs, especially in the reduction of chemicals (pesticides and oenological inputs). Once these challenges are overcome, the agroecological transition will be enabled. Adaptation to stricter European regulations on more severe production conditions at the vineyard level and the consequent additional costs are also considered challenging to the transition. Considering country differences, overall, Italians do not agree with these perceptions, while the French and Portuguese do agree. There are no particular age and gender differences or interactions. However interactions between country and age reveal that Italians under 34 years old do not agree, while Portuguese 35- to 49-year-olds and French respondents under 34 years old generally agree. Interactions between country and gender show that Italian respondents who are not women do not agree, while French and Portuguese respondents who are not women agree. Overall, representatives of public administration share these perceptions. In Italy, the public administration representatives agree, while the representatives of research institutes and the 'others' group of stakeholders do not. In Portugal the suppliers agree, and in France the representatives of research institutes 'others' group do not.

4.4 Regulations and standards

Finally, those who believe the agroecological transition will be achieved with more strict environmental regulations, controls and standards (model 4) perceive the main challenges to be reducing chemicals to meet societal needs in this regard and adapting to European regulations. Challenges that can drive the agroecological transition are also associated with the reorientation of specifications from private labels and standards (PDOs and IGPs) in the direction of sustainable production. The expansion of vineyards to new areas and the increase in farms' surface areas are also issues to be faced. This group believes that the development of more resistant varieties for the vineyards (variable **c2**) could be a driver of pesticide reduction that would lead to the agroecological transition. However, a certain degree of scepticism regarding the resistant varieties is also present, as variable c1 reveals that further adoption of resistant varieties in wine production might cause problems for the reputation of wines and their overall acceptability to consumers. Italians most commonly share these perceptions, while the French do not. Younger respondents (less than 34 years old) also share these perceptions, while those between 50 and 64 years old do not. There are no gender differences. Interactions reveal that young Italians (less than 34 years old) agree while French respondents between 35 and 64 years old do not. Italians of all genders share these perceptions, while not all genders of French respondents do. Respondents under 34 years old who are not women share these perceptions, while respondents between 50 and 64 years old who are not women do not. In Italy, representatives of public administration, producers, research institutes and the 'others' group of stakeholders share these perceptions. However, in France, representatives of suppliers, associations and producers do not.

5. ORGANIC CERTIFICATION VERSUS RESISTANT VARIETIES

This section uses ordinal logistic regressions to investigate the relationships between the stakeholders' perceptions of organic certification and resistant varieties in wine production. Accordingly, two models were estimated and in each model the dependent variable is the direct stakeholders' responses to question 7 'Organic certification will become the environmental standard' (Table 4) and to question 1 'Resistant grape varieties are a credible solution to achieve a significant reduction in pesticide use' (Table 5) from part III of the questionnaire. These were regressed in the components (as independent variables) defined in Section 4 and in the socioeconomic variables. The components to which variables 7 and 19 contributed the most in the PCA, b2 and c2 respectively, were not included in the respective models to avoid endogeneity issues. Results are shown in Table

Table 7. Results of ordinal logistic regressions for perceptions of organic certification and resistant varieties.

x	Variable name	Organic certification will become the environmental standard	Resistant grape varieties are a credible solution to achieve a significant reduction in pesticide use
a1	Territory and culture	0.04	0.10*
a2	Reducing chemicals	0.11*	0.02
a3	Consumers' and retailers' needs	0.07	0.06
a4	European regulation	0.08	0.02
a5	Decline of vineyards and yields	– 0.10	0.17*
a6	New production areas	0.05	– 0.09
b1	BIO not suitable for wine	– 1.06***	0.10*
b2	**BIO challenges to grow**		0.24***
b3	BIO is a widespread label with competitors	0.02	0.33***
b4	BIO alternatives	0.24***	0.01
c1	RV low reputation and acceptability	0.23***	– 0.77***
c2	**RV driver of pesticide reduction**	0.32***	
	Country	0.08	– 0.12
	Age	0.16*	– 0.17*
	Gender (1 = women)	0.16	– 0.47**
	Sector	0.03	0.02
	Cut1 constant	– 2.70***	– 5.32***
	Cut2 constant	– 0.26	– 3.37***
	Cut3 constant	1.67***	– 2.05***
	Cut4 constant	4.80***	0.81**
	Pseudo-R^2	0.242	0.183
	Prob > Chi^2	0.0000	0.0000

NB: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

7. For each independent variable, the table shows the partial regression coefficients.

The results show that stakeholders recognising that organic certification will become the environmental standard also agree that reducing chemicals in production and processing is one of the main challenges to enhancing sustainability in wine production. They believe that the sector should move in the direction of producing more 'nature' wines and the specifications of PDOs and IGPs should be reoriented in the direction of sustainable production. As expected, they also do not agree that organic production is unsuitable for wine production. They believe that resistant varieties can support pesticide reduction, but also have concerns that these varieties might have problems with low consumer acceptability and risk the qualitative reputation of wines, probably being assimilated to genetically modified organism by less informed consumers. Interestingly, they think that other certifications such as biodynamic or natural wines risk replacing organic certifications, especially because of the high prices of adopting these schemes. Overall, older respondents support these perceptions, and there are no country, gender or sector differences.

The stakeholders who believe that the resistant grape varieties are a credible solution to achieve a significant reduction in pesticide use see the decline of vineyards and yields as an important challenge. Strengthening the cultural character of the wines and the territorial heritage linked to the viticulture and preserving the landscapes attached to the wines are also concerns for this group. They do not believe that resistant varieties can cause problems of reputation and credibility for the wines. Furthermore, they agree that organic labels are not limited to specific types of wine, but concern all types of wine on the quality and price scale and the BIO logo is the most well-known certification among wine consumers for pesticide reduction. However other more general environmental/sustainability certifications, such as HVE (in France) and ISO, also tend to become widely distributed. In addition, the repeated use of copper can be a serious problem for societal credibility in organic certification. Contradictorily, these stakeholders believe that organic production is not suitable for wines, but still see organic certification as establishing itself as the environmental standard. However, it can only develop on a large scale through significant public subsidies

because it comes with several challenges. In this regard, they are sceptical that the evolution to more strict regulations will make it impossible to produce wines in certain regions and that the high risks linked to organic production can only be bearable for companies already well-established in the market. Younger respondents and those who are not women most commonly share these perceptions.

6. CONCLUSIONS AND POLICY IMPLICATIONS

This article has demonstrated how the agroecological transition is identified as a priority issue by stakeholders overall, especially regarding the reduction of pesticides. However, there are notable differences between the three European countries (France, Italy, Portugal) that were the focus of our survey. The stakeholders emphasise different drivers for the ecological transition. For example, French and Portuguese stakeholders (but not Italians) place significant importance on the market and societal pressures as catalysts for this transition. Another example is that professionals, unlike other stakeholders, in some countries do not consider themselves capable of changing practices to reduce pesticide use. In addition, in extreme cases, stakeholders clearly state that the agroecological transition cannot evolve under regulatory constraints.

The European survey tested two types of technical and organisational solutions that could incentivise companies and contribute to regulatory changes: (i) the development of organic certification and (ii) genetic research that would enable the development of varieties resistant to fungal diseases. In viticulture in 2022, organic certification accounted for more than 10 % of production in the three countries considered (especially in France and Italy, and to a lesser extent in Portugal). However, this certification has recently experienced a slight decline due to inflationary pressures, and it faces competition from other certifications on environmental and health issues. In all three countries, alternatives such as 'pesticide residue free', HVE and Terra Vitis in France, VIVA and Equalitas in Italy and Proteção Integrada in Portugal have emerged. Nonetheless, according to our survey, organic certification remains the most popular choice, particularly when it comes to meeting market expectations.

Concerns were also identified regarding the acceptability of resistant grape varieties, which are often presented as an acceptable solution as long as they are not considered genetically modified organisms. This distinction is not applicable to the new genomic techniques (NGTs) currently being discussed by the European Commission. In addition, there is a concern that nature might find a way to bypass these resistances. Market acceptability, particularly in relation to wine quality, is undoubtedly the most significant barrier to the development of resistant grape varieties [9]. This point is particularly emphasised by the stakeholders. In fact, regardless of stakeholder or nationality, this innovative solution of resistant varieties is perceived as very credible, and there are great hopes for it. It is worth noting that stakeholders who believe in the significant power of regulations do not consider organic certification to be the most well-known label and are in favour of deploying these innovative grape varieties. Resistant varieties are seen as a solution supporting the development of organic production.

Our results indicate that both organic production and resistant varieties are valuable options for reducing pesticide usage in viticulture, benefiting different groups of stakeholders. Therefore, sectoral policy should support the development of the knowledge, skills and tools required for the sustainable advancement of these diverse approaches to viticulture. Additional research efforts are needed to fill the gaps that currently hinder the full exploitation of their potential in terms of reducing the environmental impact of wine production.

In the EU, the organic area under vine surged remarkably (+55%) between 2013 (244 000 ha) and 2019 (379 000 ha) [22], establishing a trend consistent with the farm-to-fork strategy objectives. However, it should be noted that the adoption of organic production and resistant varieties alone may not result in a substantial reduction in pesticide volume. This raises concerns, as certain substances can harm soil fauna and, when leaked into groundwater, can endanger aquatic species [23]. In addressing this issue, the EU action plan for the development of organic production has already outlined the sectoral policy's need to deal with alternatives to contentious inputs and other plant protection products.

Section 3.3 of the action plan emphasises the importance of exploring pathways to phase out or replace contentious inputs in organic farming, such as copper, and developing alternatives to these products to enable organic farmers to protect their crops. Consequently, starting in 2023, the Commission intends to allocate funding under Horizon Europe for research and innovation projects on alternative approaches to contentious inputs, with a particular focus on substances such as copper, based on European Food Safety Authority evaluations.

In addition, since 2022, the Commission has promoted, where appropriate, the use of alternative plant protection products containing active biological sub-

stances through strengthened farm advisory services, notably agriculture knowledge and innovation systems. Furthermore, efforts will be made to provide risk management tools to address this issue effectively.

Concerning the new hybrid resistant varieties, new fungus-resistant grapevine varieties still represent an immature technology whose adoption requires investments with a long payback period [24]. The stability of the resistance to / tolerance of the pathogens targeted is unknown, and a strong research effort is even now devoted to obtaining new fungus-resistant grapevine varieties with multiple genes for resistance [25]. Moreover, the implications of using such new varieties regarding other pathogens are not yet clear. On the other hand, the choice of new varieties is now larger, despite still being rather small compared with the huge differences in wine styles, soil and climate conditions of viticulture. Therefore, the conditions exist for the use of these new varieties, perhaps in limited shares, in the production of test PDO wines, enabling the accumulation of experiences in order to discover the optimal viticulture and oenological practices to adopt and thereby opening the way for their sustainable introduction into the PDO product specification. This is already happening in Champagne, where the 'Voltis' variety is under observation.

Furthermore, NGTs are candidates for the agriculture of the future, with the aim of introducing resistant crops and ensuring food even in cases of prohibitive climatic events, all while protecting environmental sustainability. These could support organic production, especially in years with prohibitive climatic conditions in which organic farming treatments do not achieve the desired results. The Commission's 2021 study on NGTs showed that, as regards NGT-produced plants and related products, current legislation is no longer fit for purpose and needs to be adapted to scientific and technological progress [26].

The question of names and the possibility of allowing the use of hybrids in indications of geographical origin remain unsolved problems and are arousing considerable debate in EU Member States. Opinions often reflect the environmental conditions in which cultivation takes place. In regions with wetter climates, which accentuate the pressure of fungal diseases, it is understandable that using a name reminiscent of a well-known European variety is extremely advantageous in supporting the commercial spread of resistant hybrids. However, the introduction of hybrids into the PDO product specifications is not a straightforward process. The PDO product specifications should be discussed and approved locally and later approved by the Commission. Moreover, making decisions locally regarding the use of hybrids can be difficult, especially in Mediterranean regions, where the use of hybrids is frequently a source of concern. For example, in Italy, national legislation still prohibits the introduction of hybrids into the production of PDO wines, despite the change in EU general regulations.

Sectoral policy may play a crucial role in removing these drawbacks and facilitating a not-marginal diffusion of resistant varieties. Medium-/long-term genetic research programmes should be supported to obtain new fungus-resistant grapevine varieties with multiple genes for resistance (resistance gene pyramiding [27]). The replanting of vineyards with these varieties should be supported through interventions for the restructuring and conversion of vineyards. The operational groups established within the European Innovation Partnership for Agricultural Productivity and Sustainability, which has been relaunched by the CAP reform, should be encouraged to facilitate the exchange of experiences among producers and other stakeholders. This exchange can help improve knowledge of vineyard and winemaking management, and uncover site-specific solutions for various issues.

The survey sample was collected in 2018 and 2019, but this does not invalidate the results, as nothing substantial has changed since then in terms of the consequences of new regulations or shared experiences. While the area under vine planted with new resistant hybrids has grown at high rates in many regions over the past 5 years, it is still relatively small. Therefore, stakeholders' knowledge and awareness of this type of innovation is almost the same as when the data used in our analysis was collected.

Regarding the potential of NGTs as a new agroecological option for viticulture, the current scenario is quite similar to that of 2018–2019. It is true that the farm-to-fork strategy is open to these technologies, and the Commission is working on a proposal to regulate plants obtained through these techniques, amending Regulation (EU) 2017/625 ([5]). However, the legislative process is far from being finalised, and field tests are to

[5] Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products, amending Regulations (EC) No 999/2001, (EC) No 396/2005, (EC) No 1069/2009, (EC) No 1107/2009, (EU) No 1151/2012, (EU) No 652/2014, (EU) 2016/429 and (EU) 2016/2031 of the European Parliament and of the Council, Council Regulations (EC) No 1/2005 and (EC) No 1099/2009 and Council Directives 98/58/EC, 1999/74/EC, 2007/43/EC, 2008/119/EC and 2008/120/EC, and repealing Regulations (EC) No 854/2004 and (EC) No 882/2004 of the European Parliament and of the Council, Council Directives 89/608/EEC, 89/662/EEC, 90/425/EEC, 91/496/EEC, 96/23/EC, 96/93/EC and 97/78/EC and Council Decision 92/438/EEC (OJ L 95, 7.4.2017, p. 1).

begin in the coming months. Therefore, in the public debate, the new varieties that could emerge from these techniques are still seen as futuristic, despite the confidence of some researchers.

Nevertheless, the results presented here suggest the need for further research in several areas. Firstly, there is a need for studies on consumer acceptance and preferences for wines that are made at least partially from hybrid grapes. These studies should aim to analyse consumers' reactions and attitudes towards these wines in natural conditions. Secondly, there should be targeted efforts to develop a protocol that can accurately assess the sensory similarities and differences between selected new hybrids and traditional *Vitis vinifera* varieties. This would provide a rational basis for planning experiments involving the substitution of grape varieties in PDO product specifications. Such a tool would also be valuable when new varieties or clones derived from NGTs become available. Finally, once these new varieties or clones are truly accessible, potentially in the next 5 years, and the relevant EU legal framework is consolidated, it will be of paramount importance to study the opportunities and risks associated with the adoption of these innovations.

DISCLAIMER

The opinions expressed are those of the author(s) only and should not be considered as representative of the European Commission's official position.

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SUPPLEMENTARY MATERIAL

Table A1. Principal component loadings (orthogonal varimax rotation) of 'perceptions about agroecological transition'.

Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
Q1	-0.0281	-0.0167	0.6942	0.0184	0.2106
Q2	0.0043	0.0082	0.6918	-0.0141	0.2092
Q3	0.3208	0.2541	0.0132	-0.2868	0.5828
Q4	-0.1515	0.5904	0.04	0.0696	0.3936
Q5	0.5893	-0.0727	-0.0316	0.0831	0.3504
Q6	0.2915	0.1289	0.1031	0.0159	0.6959
Q7	0.2125	-0.1373	0.0832	0.412	0.5981
Q8	0.1501	0.4453	0.0579	-0.2461	0.5418
Q9	0.6063	-0.0383	-0.022	-0.0127	0.3294
Q10	-0.0046	0.5711	-0.0895	0.1553	0.3464
Q11	-0.0468	0.1028	0.0537	0.5659	0.37
Q12	0.0589	0.0956	-0.0659	0.5748	0.3829

Table A2. Principal component loadings (orthogonal varimax rotation) of perceptions about "what importance is accorded to environmental issues among other issues".

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
Q1	0.0912	0.2001	0.0173	-0.0538	0.3826	0.0121	0.5721
Q2	0.3571	-0.1911	-0.0063	-0.0333	0.0042	0.1869	0.566
Q3	-0.0872	0.0104	0.0126	-0.0177	0.6055	0.1256	0.3824
Q4	-0.0059	0.4827	0.0138	0.0113	0.1086	-0.1535	0.42
Q5	0.1185	0.3263	-0.123	-0.0101	0.2497	0.0441	0.4985
Q6	-0.1462	0.3033	0.265	0.0937	-0.2968	0.2611	0.4557
Q7	-0.1411	0.4608	-0.0319	0.0588	-0.1562	0.0068	0.563
Q8	0.4577	-0.0581	-0.0901	0.0881	-0.0195	-0.0404	0.4656
Q9	0.0322	0.0237	0.5828	-0.0602	-0.0208	-0.1648	0.4005
Q10	0.0407	-0.0624	0.3699	0.0277	0.3348	-0.1062	0.4562
Q11	0.3793	0.0695	0.1399	0.0938	-0.1818	-0.0491	0.4766
Q12	0.3765	0.0932	0.1451	-0.019	-0.1571	-0.0307	0.5035
Q13	0.0094	0.0091	0.0469	0.5623	0.011	0.0067	0.3431
Q14	-0.0476	-0.0546	0.0109	0.4511	0.2381	0.0818	0.3937
Q15	0.0466	0.0393	-0.0657	0.6196	-0.1136	0.0181	0.3432
Q16	0.096	0.4047	-0.0159	-0.016	0.073	-0.0533	0.5447
Q17	0.0126	-0.1194	0.4043	0.1461	0.1743	-0.1094	0.4577
Q18	0.2096	0.2719	-0.0195	-0.1075	0.0255	0.1799	0.5497
Q19	0.4471	-0.0117	-0.0582	-0.0055	0.082	-0.0325	0.4757
Q20	-0.0971	0.0059	0.4318	-0.0737	-0.0981	0.4004	0.4132
Q21	0.1905	-0.0092	0.1149	-0.1289	0.0101	0.3149	0.6713
Q22	-0.0005	-0.0369	-0.1179	0.056	0.085	0.7052	0.3482

Table A3. Principal component loadings (orthogonal varimax rotation) of perceptions about "Focus on organic certification".

Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
Q1	-0.1519	0.2526	0.429	-0.28	0.4648
Q2	-0.3946	0.0363	0.1265	0.2047	0.489
Q3	-0.0278	0.2671	-0.0504	0.3808	0.5276
Q4	-0.0455	-0.0629	0.0779	0.673	0.4252
Q5	-0.102	-0.1385	0.5307	0.0552	0.5033
Q6	0.2315	0.0937	0.3226	-0.1435	0.6622
Q7	-0.4579	0.2749	0.0246	0.0476	0.4149
Q8	-0.0533	0.1922	0.2556	0.0763	0.7795
Q9	0.2752	0.2102	0.0259	0.0171	0.4732
Q10	0.0749	0.3881	0.0825	-0.034	0.5551
Q11	0.2615	0.0863	0.1106	0.1069	0.605
Q12	0.1657	-0.0906	0.5043	0.1801	0.543
Q13	-0.1554	0.4933	-0.037	0.0739	0.5158
Q14	0.3169	0.1314	0.0227	0.0068	0.5003
Q15	0.3794	0.0251	0.0358	0.1021	0.3984
Q16	0.2743	0.1496	0.0172	0.0663	0.5337
Q17	0.071	0.4593	-0.1618	-0.1787	0.4884
Q18	0.1262	0.1184	-0.1896	0.3905	0.4806

Table A4. Principal component loadings (orthogonal varimax rotation) of perceptions about "Focus on resistant grape varieties".

Variable	Comp1	Comp2	Unexplained
Q1	-0.1112	0.5281	0.3738
Q2	0.3809	-0.0838	0.368
Q3	0.3713	-0.0648	0.4165
Q4	0.3362	0.0719	0.6109
Q5	0.3702	0.0151	0.4884
Q6	0.3225	-0.1513	0.4633
Q7	0.3322	-0.007	0.5738
Q8	0.0565	0.6772	0.3186
Q9	0.3758	0.1464	0.5413
Q10	-0.1214	0.3388	0.6699
Q11	0.2847	0.2947	0.7247

Table A5. Results of multivariate regressions for perceptions of agroecological transition (full table with interactions).

x	Variable names	[y1] Technology and financial incentives	[y2] Producers' information and awareness	[y3] Society and consumers' pressure	[y4] Regulations and standards
a1	Territory and culture	0.17***	0.20***	0.03	-0.06*
a2	Reducing chemicals	0.05	0.26***	0.25***	0.31***
a3	Consumers and retailer's needs	0.08*	-0.02	0.13***	0.00
a4	European regulation	0.05	0.00	0.08*	0.11***
a5	Decline of vineyards and yields	0.03	0.05	-0.03	-0.03
a6	New production areas	0.19***	0.12**	-0.02	0.09*
b1	BIO not suitable for wine	-0.10***	-0.06*	-0.10***	-0.13***
b2	BIO challenges to grow	0.26***	0.03	0.06	0.01
b3	BIO widespread label with competitors	-0.07	0.00	0.07	0.06
b4	BIO alternatives	0.10*	0.12**	0.04	0.05
c1	RV low reputation and acceptability	0.00	0.03	-0.04	0.05*
c2	RV driver of pesticide reduction	0.03	0.01	0.02	0.09*
	Italy	(base)			
	Portugal	-0.81	-0.55	0.48	-0.69
	France	-0.23	-0.29	1.46*	-0.19
	Less than 24 years old	(base)			
	Between 25 and 34 years old	-0.12	0.30	0.26	-0.38
	Between 35 and 49 years old	-0.05	0.17	0.52	-0.82**
	Between 50 and 64 years old	-0.22	0.04	0.65*	-0.84**
	65 years old or more	-0.26	0.73*	0.86**	-0.54
	IT # Less than 24 years old	(base)			
	IT # Between 25 and 34 years old	(base)			

(Continued)

Table A5. (Continued).

x	Variable names	[y1] Technology and financial incentives	[y2] Producers' information and awareness	[y3] Society and consumers' pressure	[y4] Regulations and standards
	IT # Between 35 and 49 years od	(base)			
	IT # Between 50 and 64 years old	(base)			
	IT # 65 years old or more	(base)			
	PT # Less than 24 years old	(base)			
	PT # Between 25 and 34 years old	0.15	0.56	-0.29	0.45
	PT # Between 35 and 49 years od	0.65	0.34	-0.30	0.59
	PT # Between 50 and 64 years old	0.64	0.26	-0.63	0.45
	PT # 65 years old or more	0.22	-0.68	-1.41	0.19
	FR # Less than 24 years old	(base)			
	FR # Between 25 and 34 years old	-0.68	-0.83	-0.79	-0.40
	FR # Between 35 and 49 years od	-0.70	-0.44	-1.26**	-0.19
	FR # Between 50 and 64 years old	-0.47	-0.16	-1.28**	-0.31
	FR # 65 years old or more	-0.68	-0.95	-1.87***	-0.33
	Gender - Otherwise	(base)			
	Gender - Women	-0.50	-0.04	0.04	-0.39
	IT # Otherwise	(base)			
	IT # Women	(base)			
	PT # Otherwise	(base)			
	PT # Women	-0.25	-0.35	-0.37	0.34
	FR # Otherwise	(base)			
	FR # Women	-0.05	0.04	-0.56**	-0.20
	Otherwise # Less than 24 years old	(base)			
	Otherwise # Between 25 and 34 years old	(base)			
	Otherwise # Between 35 and 49 years od	(base)			
	Otherwise # Between 50 and 64 years old	(base)			
	Otherwise # 65 years old or more	(base)			
	Women # Less than 24 years old	(base)			
	Women # Between 25 and 34 years old	0.94*	0.31	0.28	0.28
	Women # Between 35 and 49 years od	0.66	0.21	0.26	0.50
	Women # Between 50 and 64 years old	0.37	0.20	-0.04	0.69
	Women # 65 years old or more	1.56	0.76	0.95	0.19
	Public Administration	(base)			
	Associations	-0.26	-0.09	-0.50	-0.42
	Producers	-0.28	-0.19	-0.42	-0.21
	Suppliers	-0.03	-0.27	-0.69*	-0.26
	Research institutes	-0.23	-0.17	-0.82**	0.08
	Others	-0.19	-0.35	-0.65**	-0.06
	IT # Public Administration	(base)			
	IT # Associations	(base)			
	IT # Producers	(base)			
	IT # Suppliers	(base)			
	IT # Research institutes	(base)			
	IT # Others	(base)			
	PT # Public Administration	(base)			
	PT # Associations	-0.05	0.13	0.49	0.28
	PT # Producers	0.40	0.10	0.28	-0.01

(Continued)

Table A5. (Continued).

x	Variable names	[y1] Technology and financial incentives	[y2] Producers' information and awareness	[y3] Society and consumers' pressure	[y4] Regulations and standards
	PT # Suppliers	-1.31	1.32	2.68*	-0.84
	PT # Research institutes	0.07	0.22	0.45	-0.48
	PT # Others	0.17	0.46	0.65	-0.17
	FR # Public Administration	(base)			
	FR # Associations	1.25*	0.82	0.13	0.10
	FR # Producers	0.57	0.41	-0.01	-0.14
	FR # Suppliers	0.52	0.82	0.24	-0.02
	FR # Research institutes	0.89	0.70	0.62	-0.09
	FR # Others	0.28	0.90*	0.36	0.18
	constant	0.43	0.03	-0.17	1.00**
	R-sqr	0.293	0.313	0.284	0.317