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Ten years of Bio-Based and Applied Economics: a story of successes, and more to come

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Bio-based and Applied Economics, the official journal of the Italian Association of Agricultural and Applied Economics, has been established in 2011: the Journal has constantly hosted high quality manuscripts, published by scholars aiming at contributing to the debate on topics that have been relevant for the Association.

In less than ten years BAE has become a well-established international journal, indexed in several scientific databases, such as Scopus and Emerging Sources Citation Index™ of Web of Science. Across years, the Journal has repeatedly devoted attention to innovative aspects for the profession, with a special attention to the definition and evolution of the bioeconomy (Schmidt et al., 2012), lately as the "*evolutionary process of transition from systems of mining non-renewable resources to farming renewable ones*" (Zilberman et al., 2013). The importance of bioeconomy is increasing more and more exactly because its objectives are converging towards those of the new paradigm of economic growth: the circular economy (Aguilar et al., 2018). As from the very first articles hosted in the opening and in subsequent issues, such as those authored by Viaggi (2012), Romano (2012) and Esposti (2012), among others. The large number of submissions that the Journal has attracted has allowed to publish research papers from many very traditional areas such as agri-food system analyses, demand and production economics (e.g. Sckokai and Varacca, 2012), price, trade and policy analyses (e.g. Matthews, 2013; Jafari et al., 2018; Santeramo and Cramon-Taubadel, 2016). In addition, the Journal has hosted several manuscripts analysing fields closely connected with the agricultural and applied economics, such as environmental economics, behavioural economics, political economy, development economics, health economics, or focused on important and timely topics such as changes in the agri-food systems and methodological challenges in analysing them (e.g. Heckelei et al. 2012; Donati et al., 2013; Scoppola, 2015). Such a broad range of topics has allowed the Journal to become an agora for the scientific debate, and such a prominent role is very much strengthened by the Open Access nature of the Journal that, coupled with absence of submission and publication fees, guarantee that manuscripts are accessible to all interested readers, without limitations of any kind.

After a decade of great achievements, the Board has launched several initiatives (Moro et al., 2019) such as, among others, words mention to the most impactful papers hosted in BAE and the recurrent recognition of one "Best Paper in BAE". The first edition of these awards has been in 2021. Starting from the next years a special mention will also be dedicated to the reviewers that have excelled in their (extremely valuable) reviewer activities. The support of competent reviewers has been one of the main resources on which the Journal has counted to become a very well-established field Journal.

BAE is not only a fast-growing Journal, but also a resilient, fast-changing environment. After a deep reorganization of the Board, composed by the two Editors in Chief, five Associate Editors, and the editorial assistant, and a major transition to a new online platform, BAE has just renewed its graphical aspect to provide more information to the readers, and emphasize the rigor and transparency of the double-blind peer review process, a mechanism that ensure the high quality of the manuscripts hosted in BAE. Furthermore, the Journal will host more articles, organized in four issues per year: a signal that the growth in quality is solid and promising.

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The best has yet to be described. Among the new initiatives we proudly announce, starting form the following issues, BAE will host a series of invited reviews aimed at synthesizing the topics debated in BAE as well as at emphasizing the status of the art of the Bioeconomy, a repeated tradition for the Journal (e.g. Romano, 2013; Viaggi, 2016; Sckokai, 2016). Following the debate on bioeconomy is of utmost importance, due to the vivid attention that the topic is receiving not only in Europe (Wessler et al., 2017; D'Adamo et al., 2020; Stegmann et al., 2020), but also in other continents (Asada and Stern, 2018; Zilberman et al., 2018).

Moreover, BAE aims at publishing invited reviews on behavioural and risk management in agri-food systems issues in agri-food systems, themes that have attracted several important submissions (e.g. Coletta et al., 2018; O'Donoghue et al., 2020; Giampietri et al., 2020) and are highly debated in top field journals (Howley , 2015; Vigani, and Kathage, 2019; Sok et al., 2021).

In order to follow the debate on vulnerability, resilience and systemic changes in the agri-food sector, greatly animated by Allouche (2011), Upton et al. (2016), Pingali and Sunder (2017) and Shobe (2020), the Journal will continue to dedicate attention to the systemic changes in the agro-food systems, and to the resilience of the agri-food systems, updating the debated that has been animated in BAE by several authors such as, among others, Sarris (2013), Alvarez and Arias (2015), Avanzini et al. (2018) and Romano et al. (2019).

The Board has also solicited reviews to synthesize the state of the literature devoted to speculating on policy and trade dynamics (e.g. Peterson et al., 2000; Petit, 2008; Sun and Reed, 2010; Pannell and Claassen, 2020), whose debate dates back to the first issues of BAE (e.g. Moschini et al., 2012; Dwyer, 2013), but has never ended (e.g. Carbone et al., 2015; Olper, 2016), and, indeed, has increased in prominence (e.g. De Maria, 2018; Macedo et al., 2019).

Last, but not least, the Journal will dedicate space to review the state of the art on the rural development and on nutrition and health issues, whose debate has deep roots in BAE and it is quite promising and vivid (e.g. Barreiro-Hurle et al., 2010; Irwin et al., 2010; Camaioni et al., 2013; Sckokai et al., 2014; Bertolini and Pagliacci, 2017; Cerroni et al., 2019; Frison and Clément, 2020).

The Board is proud of the journey that the Journal is facing and will continue to work to ensure that BAE will continue to be an independent and Open Access environment to debate and disseminate rigorous scientific findings, and authoritative critical views. As closing note, the Editors in Chief express their gratitude to the scientists who have made possible the ambitious project of Bio-based and Applied Economics to become a solid reality.

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The capitalisation of decoupled payments in farmland rents among EU regions

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Abstract. We study the capitalisation of subsidies in the European Union (EU) regions in the years 2006-2008, the first years after the introduction of the Common Agricultural Policy (CAP) 2003 reform that decoupled subsidies from production and attached them to land. For this purpose, we use regional aggregated data and estimate the capitalisation rate upon the entire sample and, in a second stage, splitting the sample according to the implementation regime applied by the different EU Member States (MSs), following the three options introduced by the CAP regulations (historical, regional and hybrid model). We find that between 28 and 52 cents per Euro of additional subsidy capitalise into land prices in MSs that adopted the hybrid and the regional model, respectively. We find as well that subsidies do not capitalise in farmland prices in MSs that adopted the historical model.

Keywords: European Union, capitalisation of EU payments, land rental prices, spatial panel econometrics.
JEL codes: Q12, Q18.

1. INTRODUCTION

Farmland is by far the most valuable input in agricultural production. In the European Union (EU), land, alongside permanent crops and quotas, accounts for about 65% of total fixed assets of farms in 2012 and the figure rises to 80% when only farms specialised in field cropping are considered (European Commission - EU FADN, 2015). Accordingly, the theoretical and empirical literature paid much attention to the determinants of farmland prices.

Following the implementation of the 2003 Common Agricultural Policy (CAP) reform, EU subsidies have been decoupled from production and linked to land, increasing the likelihood that these payments get capitalised, in full or in part, in land prices and land rents (Ifft, Kuethe, & Morehart, 2015). The capitalisation of subsidies transfers the money intended to support EU agriculture out of the agricultural sector and, for this reason, the consequences of decoupling and payment harmonisation have recently become

the focus of academic and policy studies (Gocht, Britz, Ciaian, & Paloma, 2013; Graubner, 2018; Kilian, Antón, Salhofer, & Röder, 2012; Klaiber, Salhofer, & Thompson, 2017; Michalek, Ciaian, & Kancs, 2014).

With the recent 2013 reform, the CAP moved in the direction of equalising payment across farms, which translated into the reduction of the level of subsidies for most countries and an increase for the few remaining Member States (MSs) (European Commission, 2013). In implementing the 2003 reform, MSs could choose between three different implementation schemes, with only two of them guaranteeing a harmonisation of the payments. The first option (historical model) was to assign a farm-specific level of payment reflecting the historical amount of support to that farm during a reference period. In this way, the reform kept unchanged the differences in the levels of payments across farms. The second option (regional model) was to assign a flat payment per hectare to each farm allowing the payment to vary across regions but not among farms in the same region. This second implementation option resulted in the harmonisation of payments at the regional level. The third option (hybrid model) was a combination of both, with a level of payment resulting from the sum of the historical and the regional components, weighing initially more and then progressively less the historical component. Although the hybrid model, unlike the regional model, did not realise the harmonisation of payment immediately, it put forward the design of a smooth transition toward this objective. MSs that adopted the historical model or the hybrid model without completing the harmonisation of payments are now requested to make a further step in this direction. Thus, understanding the consequences of this transition for the capitalisation of the payments in land prices and rents appears of crucial importance.

The econometric literature concerned with the capitalisation of coupled and decoupled payments is interested in estimating the capitalisation rate, that is, how much the farmland prices and rents increase following a rise in the payment received. A large part of the literature refers to the US and is relatively less recent, probably because the US introduced decoupled payments earlier than the EU (Goodwin, Mishra, & Ortalo-Magné, 2012; Kirwan, 2009; Lence & Mishra, 2003; Patton, Kostov, McErlean, & Moss, 2008; Roberts, Kirwan, & Hopkins, 2003). With the only exception of Lence & Mishra (2003), which use county-level data, all studies use farm-level data. Farm-level data are also used at the EU level to investigate the capitalisation of subsidies (Breustedt & Habermann, 2011; Ciaian & Kancs, 2012; Guastella, Moro, Sckokai, & Veneziani, 2018; Klaiber et al., 2017; Michalek et al., 2014; O'Neill & Hanrahan, 2016). The farm-level evidence in the EU is heterogeneous. At the root of such heterogeneity, there is the geographical coverage of the study (the countries and regions analysed, new MSs vs old MSs), the period of the data (pre-reform vs post-reform), the methodological approach (cross-section analysis, panel data analysis, quasi-experimental approaches) and the type of agricultural support (coupled vs decoupled subsidies). Notwithstanding this heterogeneity, there is a broad consensus that payments capitalise in farmland prices. In addition to the farm-level empirical literature, there is evidence from studies using spatially aggregated data, either at a very aggregate scale, such as the country level (van Herck, Swinnen, & Vranken, 2013) or at a very disaggregated scale such as the municipality level (Kilian, Antón, Salhofer & Röder, 2012; Nilsson & Johansson, 2013).

The present work contributes to this empirical literature by exploring the relationship between farmland rental prices and decoupled subsidies in the entire EU. To get comparable results across the EU, we aggregate farm-level data at the regional level and estimate the capitalisation rate using spatial econometric models. In addition, we allow the estimated capitalisation parameter to vary among regions according to the implementation regime adopted by the reference MS. The work aims at contributing to the policy debate as well. In the most recent CAP reforms, regions appear to be the designed entities to implement the harmonisation of agricultural payments. Hence an investigation at this level is deemed appropriate to understand the potential consequences of this reform for land markets in relation to the harmonisation strategy adopted by each MS.

Approaching the issue of payment capitalisation with spatially aggregated data has drawbacks and advantages. The gain of farm-level over spatially aggregated data is that with repeated observations over time it is possible to control for unobservable heterogeneity related to the quality of land, undoubtedly among the most important determinants of the farmland price. As a drawback, such heterogeneity likely disappears when data for different land parcels are aggregated at a larger spatial scale. The availability of microdata, however, comes at the price of the limited variation of the dependent variable, farmland rents, over time, when the observed price comes from long-term rental agreements that weakly react to changes in subsidies. Hence, an advantage of using spatially aggregated data is the possibility to capture regional trends in land prices that are not subject to price stickiness. Another advantage of using aggregated data is the coherence with the policy objective of the 2003 reform, the convergence of agricultural

subsidies to a fixed per hectare amount at the regional level. As the agricultural subsidy is gradually converging to a fixed regional amount, the comparison across territories, rather than across farms, should be more suitable for understanding and analyse the capitalisation of the Single Farm Payment (SFP).

In the remainder of the paper, we briefly introduce in the next section the policy framework framed by the recent reforms and provide a description of the data and the empirical approach in section three. We present the estimation results of the spatial econometric model in section four. A discussion concludes the work.

2. THE CAP REFORM: DECOUPLING AND HARMONISATION

The CAP process of decoupling dates back to 1992, with the MacSharry reform that introduced area payments for arable crops, awarded to all farmers sowing cereals, oilseeds and protein crops, provided they were setting aside a fixed share of arable cropland. Area payments were based on regional historical yields, thus introducing heterogeneity across the EU, with the intent of keeping support at the pre-reform level. Being still linked to production and differentiated by crop, these payments were only partially decoupled. This setting was maintained under the next Agenda 2000 reform in 1999.

In 2003, under the so-called Fischler reform, a radical change of agricultural support was undertaken. Area payments converted into an SFP, whose rights were linked to land but progressively decoupled from production. The introduction of the SFP is the key element of the Fischler reform. Other important innovations are cross-compliance (i.e., payments made conditional to fulfilling a number of requirements concerning land maintenance and other agro-ecological provisions) and modulation (i.e., aiming at transferring support away from the largest farms and finance other voluntary measures of the CAP). The reform implementation followed three different schemes. In the historical scheme, the SFP simply reflected the amount of support historically received by the farm during a reference period (the three years 2000-2002), thus leaving unchanged the differences in the level of support among farms, with no redistribution within a certain area/region. Under the regional scheme, within a certain area/region the per-hectare payment was equalised, making it equal to the amount of historical support in that region divided by the eligible land. In other words, the regional scheme allowed to redistribute and harmonise support within each region

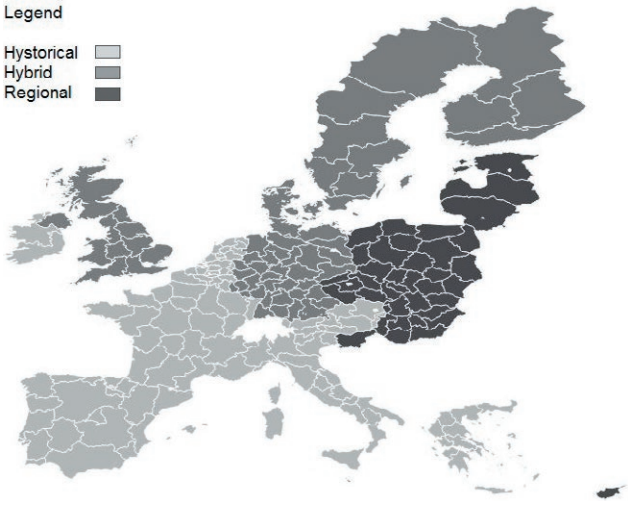

Figure 1. EU regions adopting different implementation schemes of the CAP 2003 reform.

but keeping differences across regions. Finally, the hybrid scheme was a combination of the previous two schemes; at the area/region level the per-hectare payment was made up by two components: the first computed on a historical basis, and the second computed according to the regional model. Thus, this option maintained some differences across farms, progressively reduced by transferring support from the historical to the regional component. However, a common feature of the three schemes was to preserve some payment differences across regions in the same MS. In figure 1, we report the distribution of the three implementation schemes of the 2003 CAP reform across the EU regions. The 2013 or Cioloş reform, while modifying the structure of the direct payments, aimed at a more equitable distribution of support among areas and farmers, to be achieved by mean of both a process of external convergence across MSs and a process of internal (full or partial) convergence, across farmers within the same MS or region. Through the external convergence process, by 2020 the MSs receiving less than 90% of the EU average payment in 2013 will increase such payment in order to close at least one-third of this gap and will not receive less than an agreed minimum payment level (196 euro/ha). Payments will thus become more homogenous, although not perfectly equal, across MSs. With the internal convergence process, payments are going to be harmonised within each MS, or specific regions inside each MS. Three options are available: full convergence, with a flat rate to be reached either by 2015 or by 2019 and partial convergence, in which some differences across farmers are still maintained.

3. EMPIRICAL STRATEGY AND DATA

For the empirical analysis, we borrow the theoretical framework from Lence & Mishra (2003) and use their equation 1 to estimate the capitalisation rate. The dependent variable r_{it} is the average price of land rents in region i at time t. The use of farmland rents instead of values is widespread in capitalisation studies and also brings the advantage that rents more than values can be directly related to market returns, being less sensitive to other location factors (Borchers, Ifft, & Kuethe, 2014). To explain the variation in farmland rents, we use the information on the average productivity including the X matrix, whose $j=1,2,\ldots,J$ columns represent the average productivity of the j^{th} sector weighted by the share of total area farmed in each sector. The set of variables captures the structural differences in agricultural production among European regions that can influence farmland rents. Mediterranean regions, for instance, characterised by a significant share of land employed in high-value agricultural production from permanent crops, olives, grapes, and related transformed products, are expected, other things being equal, to exhibit higher rental prices.

The variable of interest is the average per-hectare amount of subsidies (S) received by farms in region i at time t, and γ is the associated coefficient which expresses the capitalisation rate. The equation also includes region-specific effects β_i that account for structural differences among regions due to unobservable factors. Z is a matrix of control variables.

$$r_{it} = \beta_i + \sum_{k=1}^{K} \beta_k X_{k,it} + \gamma S_{it} + \delta Z_{it} + \varepsilon_{it} \quad (1)$$

Differently from Lence & Mishra (2003), who consider two agricultural outputs only, and from EU studies that consider aggregate measures of either productivity (Breustedt & Habermann, 2011) or market returns (Ciaian & Kancs, 2012), we consider multiple outputs to capture the considerable heterogeneity in the composition of aggregate agricultural production in the EU regions. More specifically, total production is divided into k=7 output categories, namely, arable crops (including cereals, proteins, potatoes, sugar beet, oilseed and industrial crops), vegetables and flowers, fruits, wines and grapes, olives, forage crops and other crops[1].

The decoupled payments are measured as the monetary amount disbursed as SFP under the Single Payment Scheme (SPS) for the old MSs (EU15) and under the Single Area Payment Scheme (SAPS) for the new MSs (EU10). Since the amount of the subsidy per hectare is perfectly known, we exclude any endogeneity caused by the problem of expectation errors discussed in Lence & Mishra (2003) and Patton, Kostov, McErlean, & Moss (2008).

The matrix Z includes a list of controls to account for characteristics expected to impact on farmland rent variation. In particular, we control for the average size of farms (*SIZE*); the average share of family labour (*FAMLAB*); the average capital per ha (*FIXASS*); the animal density (*ANIMALD*); the average share of rented to total Utilised Agricultural Area (UAA) (*RENTPROP*). We expect a negative coefficient related to farm size because larger farms have substantially more power to bargain in the land markets. At the same time, it is essential to acknowledge that large farms are more efficient and thus, willing to pay higher land rents. The outcome depends on which effect will prevail, on average. Besides farm size, family labour, and fixed assets control for the managerial approach to farming in the regions. In regions where farmers adopt a managerial approach to agricultural activity, the market for land is expected to be more dynamic. Consequently, farmland rents should be higher. The animals' density controls for the higher farmland rents generated by the demand for land for manure spreading, as a result of the nitrate directive. A higher animal density, related to more productive and profitable activities, implies an increase in the demand for land, thus driving up rents. Nonetheless, the high density of animals is also a characteristic of regions specialised in livestock production to the largest extent. The share of permanent grassland in these areas can be in fact very high, leading to a spurious negative relationship between farmland rents and animal density due to the unobserved quality of land, that may be lower in regions specialised in livestock production. Finally, the theoretical hypothesis that all land is the property of landowners and rented to farmers at the equilibrium rental price might appear simplistic, especially in some EU regions. On average, almost 50% of land used in agriculture is rented, but this figure masks considerable heterogeneity among territories in Europe (European Commission - EU FADN, 2015). The proportion of rented land controls for the increase in the average value of rents due to the limited supply of land for rent.

Following the discussion presented in the previous section, the likelihood of subsidy capitalisation is higher in case the regional model is adopted compared to the historical model. In the latter case, the extent of capitalisation is determined by the relative abundance of eligible hectares, required to activate the payment, com-

[1] The aggregation of agricultural activities in sectors is based on the classification scheme provided with the FADN data.

pared to the number of entitlements. To assess the structural differences in capitalisation rates among regions in MSs that adopted different implementation regimes, the model in equation 1 is modified allowing the capitalisation parameter γ to vary according to the implementation regime in equation 2, where *HIS*, *HYB* and *REG* are dummy variables indicating whether region *i* belong to a MS that adopted the historical, hybrid or regional model, respectively.

$$\gamma = \gamma_1 HIS_i + \gamma_2 HYB_i + \gamma_3 REG_i \quad (2)$$

Since the structural characteristics of the implementation regime may also condition the effect of the land market in general, not only of the capitalisation process, we extend the structural heterogeneity approach in equation 2 to all the parameters of the model.

Both the models in equation 1 and 2 are estimated using linear panel data models. Since the observations in the sample are related to spatial units, the standard linear model residuals independence assumptions may be violated. We thus correct the specification assuming a spatial autocorrelation structure of the residuals and estimate a spatial error model (SEM, equation 4).

$$\begin{cases} r_{it} = \beta_i + \sum_{k=1}^{K} \beta_k X_{k,it} + \gamma S_{it} + \delta Z_{it} + \varepsilon_{it} \\ \varepsilon_{it} = \lambda \sum_{j=1}^{J} w_{ij} \varepsilon_{it} \end{cases} \quad (3)$$

Alternative spatial econometric model specifications can account for unobserved spatial heterogeneity, omitted spatially correlated variables and spatial spillovers. LeSage & Pace (2009) provide an extensive review of the possible motivations leading to spatial correlation in data and an overview of testing procedures to select the correct specification based on observed data.

In this paper, we take a different perspective. The choice to consider structural heterogeneity in the deterministic part of the model, that is to allow the capitalisation and other parameters to vary depending on the implementation regime, invites to leave the spatial autocorrelation issues in the error term and to exclude the other three prevalent specifications, the spatial autoregressive model (SAR), the spatial Durbin model (SDM) and the model with the spatial lag of the covariates (SXL). In principle, it is possible to account for structural heterogeneity also in these models. That would result, however, in very complex expressions for the marginal effect, among the others, of subsidies on farmland rents and, hence, of the capitalisation rate. The SEM model, differently from the SAR, the SDM and the SXL models, is the only one that does not consider spatial processes in the deterministic part of the model and allows a direct interpretation of the coefficients as the marginal effects. This characteristic appears very useful when dealing with structural instability. However, we test the robustness of this choice (and of the results) and estimate the most common alternative to the SEM model, the SAR model.

In both the spatial models without and with the structural heterogeneity, the spatial weight matrix *W* identifies neighbourhood relationships through its elements w_{ij} that express the inverse distance from region *i* to its neighbour *j* if the distance is lower than a threshold d^* and 0 otherwise[2].

The dataset used to estimate the capitalisation effect comprises 208 NUTS regions belonging to the EU25 countries. More precisely, NUTS II classification is the territorial reference for all countries but the UK and Denmark, where NUTS I and NUTS 0 is used instead, respectively. The choice is consistent with the design of the FADN survey data, which is stratified by regions, agricultural specialisation, and size, and hence returns reliable estimates of the values of interest by aggregating at the regional or higher level[3].

Regional data are available in the FADN database for the whole period 2003-2008 for the EU15 and starting from 2005 for the EU10. However, since some countries implemented decoupling after 2005 only, data for the SPS payments are available only from 2006 for the complete set of regions. Romania and Bulgaria are excluded from the analysis because data collection started in 2007. We compute the distance between each pair of regions based on geographical coordinates available in the reference files of the Geographical Information System of the EU Commission (GISCO). Since Atlantic islands are considered too far for any spatial relation with continental regions to exist, these regions are excluded from the sample. The threshold distance to define contiguity between regions (d^*) is 500 km and is appropriate to describe the spatial structure of connectivity links, although arbitrary. In particular, the 500

[2] As usual and required, the elements of the matrix are row standardised and the diagonal elements are set to zero to exclude self-contiguity. The choice of the distance-based approach is made to avoid cases of self-contiguity only.

[3] We exclude accordingly the Local Administrative Units (LAU, in the Eurostat Nomenclature) used in Kilian, Antón, Salhofer & Röder (2012) and Nilsson & Johansson (2013) because the FADN aggregates are not representative at this level. We also exclude the country level used in van Herck, Swinnen, & Vranken (2013) because land rents vary significantly across regions of the same country, especially in some Member States (MSs), and we want to preserve this heterogeneity in our empirical analysis.

Table 1. Description of the dataset.

Variable	Description
RENT	Average rent paid (euro/ha)
AC	Output value – Arable crops (euro/ha)
VF	Output value – Vegetables and Flowers (euro/ha)
FR	Output value – Fruits (euro/ha)
WG	Output value – Wines and grapes (euro/ha)
OO	Output value – Olives (euro/ha)
FC	Output value – Forage crops (euro/ha)
OC	Output value – Other crops (euro/ha)
SFP	Average payment received under SAPS or SPS (euro/ha)
SIZE	Average farm size (ha)
FAMLAB	Share of family to total labour (%)
FIXASS	Value of Fixed Assets (Machinery and Equipment) (euro/ha)
ANIMALD	Number of animal units per ha (count in livestock equivalent)
RENTPROP	Proportion of rented UAA (%)

km cut-off distance ensures that every region has at least one neighbour and that, in turn, each row of the weight matrix has at least a non-zero element.[4]

The 208 regions in our dataset are observed for three years. To build the dataset, we used 153,069 original farm-level observations, excluding the outliers showing unreasonable values of average productivity and payments[5]. Table 1 describes the main variables used for the land rental price model, and Table 2 provides some useful descriptive statistics. The average farmland rent, which is the total rent paid by the farmers in the region excluding rent paid for quotas and other things not attached to land over the total rented area, was about 171 euro per hectare in 2006 and increased to 176 in 2008. The largest value of production per ha in 2006 accrued to farms producing vegetables and flowers followed by fruits and wines and grapes and all values changed little during the three years. This substantial heterogeneity indicates that an empirical specification that considers the composition of agricultural production is appropriate in the case of EU regions. The average value of the SFP per ha was 256 euro in 2006 and increased to 298 in 2008. The figure related to the contribution of family labour is unsurprisingly high, since, on average, almost two over three hours are worked by family members. Also, two-thirds of the available UAA in the regions is rented, and the figure looks relatively stable over time. This high proportion of rented land suggests both that an analysis of SFP capitalisation at the EU level is appropriate and that rental prices, rather than sale prices, should be considered for this purpose.

4. RESULTS

We perform the empirical estimation of the land price model using different estimators and summarise all the results in Table 3. The first column of the table reports the estimation results using the Pooled OLS, from which we get an estimate of the capitalisation rate for subsidies of 26% (26 cents per additional Euro). The estimate substantially lowers when introducing in the specification individual effects, either as fixed (second column) or random (third column) effects. Assuming fixed effects also leads to an estimate of the capitalisation rate that is not statistically different from zero. This result looks reasonable because both the rental price and the subsidy variables show very limited within variation, partly because of structural rigidities and partly as a consequence of the short time dimension of the panel.

In contrast, assuming random effects, we get a significant, although low, capitalisation rate, estimated at 4.3%. We get similar results in the case of spatial models. With both specifications (SAR and SEM), the use of fixed effects (columns 4 and 6) leads to lower in magnitude and insignificant capitalisation rates, opposite to the random effect specification (columns 5 and 7). The only noticeable difference with the non-spatial model is that the coefficient estimates for the capitalisation rate lower down to 3%.

In both spatial and non-spatial models we get positive and statistically significant coefficients for the "Arable crops" and "Vegetables and flowers" categories, but only in the spatial models, and independently of the specification, we also get positive and statistically significant coefficients for the "Fruits" and "Wines and Grapes" categories. Thus, spatial models seem more capable to capture the geographical concentration of specific productions in particular regions of Europe, typically the regions of the Mediterranean countries.

The use of spatial specifications leads to more significant results, also in the case of the control variables. For instance, it is the case of the coefficient of the FAMLAB variable, which is insignificant in the POLS model, significant in the FE model and always significant in the

[4] Alternative distances have been tested, and the estimate and significance of the capitalisation rate appears not affected. Only minor changes can be noticed in relation to the control variables.

[5] Outliers are not necessarily the result of reporting errors. Rather they are closely related to the accountancy nature of the database and appear because some monetary values may be reported in a different accounting year, for instance, in the case of subsidies, because of delayed payments.

Table 2. Summary statistics of the variables.

	2006			2007			2008		
	Mean	(SD)	[min; Max]	Mean	(SD)	[min; Max]	Mean	(SD)	[min; Max]
RENT	171.411	(124.353)	[8.25;583.57]	173.611	(123.860)	[9.82;609.81]	176.058	(124.688)	[12.03;656.35]
AC	1287.311	(1514.206)	[0;15428.92]	1499.436	(1583.810)	[0;15475.54]	1598.579	(2063.647)	[0;18560.53]
VF	10379.490	(11748.030)	[0;96182.79]	10705.340	(11094.790)	[0;70163.73]	11880.270	(13328.370)	[0;76807.57]
FR	5594.956	(6158.491)	[0;35745.33]	12143.420	(83190.780)	[0;1181033]	9896.156	(44404.570)	[0;621233.4]
WG	4142.775	(8783.751)	[0;63246.45]	5205.113	(13893.260)	[0;139150]	5161.718	(11601.920)	[0;82500]
OO	455.659	(1156.293)	[0;10062.25]	479.537	(1212.344)	[0;9379.722]	549.385	(1434.236)	[0;10297.3]
FC	181.831	(285.286)	[0;2074.19]	187.035	(245.419)	[0;1473.687]	212.475	(284.639)	[0;1359.38]
OC	29229.110	(111487.700)	[0;1249723]	34359.420	(209769.100)	[0;2865080]	16822.680	(36829.070)	[0;282031.3]
SFP	256.108	(128.571)	[31.45;626.06]	270.722	(131.702)	[36.46;610.11]	298.738	(178.626)	[47.711;1367.23]
SIZE	10.763	(28.564)	[0.05;236.99]	11.254	(30.441)	[0.08;210.84]	11.885	(34.100)	[0.07;298.81]
FAMLAB	0.677	(0.270)	[0.02;1.0]	0.672	(0.269)	[0.01;1]	0.668	(0.269)	[0.01;0.99]
FIXASS	4668.559	(6322.787)	[285.67;65261.51]	4976.150	(7887.282)	[363.92;80204.6]	5091.916	(8355.090)	[483.39;85890.15]
ANIMALD	1.129	(1.323)	[0;12.05]	1.128	(1.379)	[0;11.72]	1.152	(1.418)	[0;11.22]
RENTPROP	0.674	(0.175)	[0.26;0.99]	0.676	(0.177)	[0.23;0.98]	0.683	(0.175)	[0.17;0.97]

Table 3. Estimates of the rental price equation, EU regions, 2006-2008.

	POLS	FE	RE	SAR FE	SAR RE	SEM FE	SEM RE
X_{AC}	0.114***	0.037**	0.065***	0.036***	0.059***	0.043***	0.072***
	(0.008)	(0.017)	(0.011)	(0.007)	(0.008)	(0.008)	(0.009)
X_{VF}	0.014***	0.018***	0.014***	0.018***	0.014***	0.018***	0.013***
	(0.003)	(0.005)	(0.004)	(0.002)	(0.003)	(0.002)	(0.003)
X_{FR}	0.014***	0.006	0.009	0.007*	0.008**	0.008**	0.009**
	(0.004)	(0.012)	(0.01)	(0.004)	(0.004)	(0.004)	(0.004)
X_{WG}	0.016	0.039	0.042	0.039***	0.038***	0.033***	0.026**
	(0.014)	(0.045)	(0.035)	(0.012)	(0.012)	(0.011)	(0.012)
X_{OO}	-0.085***	0.009	0.001	0.012	0.006	0.011	0.000
	(0.027)	(0.016)	(0.01)	(0.009)	(0.011)	(0.009)	(0.011)
X_{FC}	-0.007	-0.020	-0.024	-0.020	-0.007	-0.031	-0.016
	(0.028)	(0.044)	(0.031)	(0.019)	(0.021)	(0.019)	(0.023)
X_{OC}	-0.038*	-0.068**	-0.065**	-0.068***	-0.063***	-0.069***	-0.063***
	(0.019)	(0.027)	(0.026)	(0.006)	(0.007)	(0.006)	(0.007)
SFP	0.261***	0.007	0.043**	0.007	0.030**	0.004	0.032**
	(0.025)	(0.022)	(0.019)	(0.009)	(0.012)	(0.01)	(0.015)
SIZE	-1.910	-3.707	-9.024*	-5.299	-11.100***	-7.806*	-16.020***
	(3.222)	(9.246)	(5.178)	(4.229)	(3.362)	(4.437)	(4.148)
FAMLAB	-16.960	-124.900**	-44.367	-120.345***	-72.557***	-126.988***	-98.005***
	(18.733)	(55.197)	(31.01)	(21.981)	(18.662)	(21.854)	(20.803)
FIXASS	12.470**	14.328	26.844***	12.928***	18.333***	12.644**	21.791***
	(5.718)	(11.32)	(6.689)	(4.766)	(4.862)	(4.883)	(5.637)
ANIMALD	28.176***	1.439	14.130***	1.830	10.995***	2.194	11.304***
	(2.804)	(5.859)	(4.266)	(2.437)	(2.505)	(2.415)	(2.629)
RENTPROP	-155.691***	-124.286*	-134.619***	-121.159***	-127.441***	-126.147	-138.694***
	(21.964)	(69.663)	(37.023)	(22.724)	(21.196)	(22.422)	(22.535)
				0.206***	0.557***		
				(0.062)	(0.044)		
						0.346***	0.950***
						(0.068)	(0.018)

Notes to table: SE in parenthesis. ***, ** and * indicate statistical significance at 1%, 5%, and 10% levels respectively. ρ and λ are the spatial parameters in thee equations 2 and 3.

spatial FE and RE models. For the FIXASS and RENTPROP variables, the coefficients are weakly significant, or altogether insignificant, when estimated with FE and turn highly significant in all the spatial models. At least for the FIXASS variable, the FE estimation in both spatial and non-spatial models underestimates the coefficient compared to the RE specification. The same happens with the ANIMALD and SIZE variables, which are significant in RE models only.

The more significant results obtained with the use of RE specifications in spatial and non-spatial models find justification in the very short time dimension of our panel, which causes structurally low within variation in all variables. Building on this evidence, we prefer to resort to RE effect specification. Moreover, we note from the results in Table 3 that all the coefficients have the correct signs and similar magnitude across all specifications. Considering the spatial models only, we get positive estimates of the coefficients associated with all the weighted outputs but "Other crops" which makes sense, since it is our residual category. We also get a positive estimate of the coefficient related to the SFP variable. The negative coefficient related to SIZE means that larger farms pay, on average, lower rents; the negative coefficient for FAMLAB and the positive one for FIXASS indicate that more managerial farms pay lower than expected rents, other things equal; the negative coefficient for RENTPROP is consistent with the hypothesis on the functioning of land markets. This evidence allows concluding against the hypothesis of a severe unobserved heterogeneity bias caused using random effects.

Confronting the spatial models, both the SAR and the SEM produce equivalent results, at least regarding estimated coefficients[6]. In addition, the spatial parameters are always positive and statistically significant. It is possible to notice that the estimated spatial parameter is higher in the RE model, and that provides an indication that the spatial component in the RE models also accounts for the spatial heterogeneity otherwise accounted for by the FE.

One significant advantage of the SEM specification over the SAR is that it allows easy manipulations of the model in the case of sample splitting, representing the most convenient way to manage the structural instability of the parameters[7]. We benefit of this property of the SEM specification to investigate the extent to which the estimated capitalisation rate varies across groups of regions defined according to the choice made by each MS on the implementation scheme of the SFP.

In Table 4, we report the estimation results that consider the structural heterogeneity of the parameters across the three groups of regions in figure 1, adopting the regional, hybrid and historical schemes, respectively. In other words, we allow the coefficients β, γ, and δ in equation 3 to vary across schemes (equation 4).

We find out less significant results related to the sectoral productivities of regions. The fact that we allow for time-invariant effects across regimes with regime-specific intercepts may explain this evidence, assuming that the differences in productivities among regions in

Table 4. Estimation results by implementation regime, EU regions, 2006-2008.

	regional	hybrid	historical
Intercept	-32.130	125.905	63.993
	(113.334)	(117.884)	(54.181)
X_{AC}	0.028	0.095***	0.079***
	(0.034)	(0.023)	(0.009)
X_{VF}	0.075	0.027**	0.010***
	(0.091)	(0.012)	(0.003)
X_{FR}	0.044	0.001	0.022***
	(0.18)	(0.007)	(0.007)
X_{WG}	0.048	-0.001	-0.002
	(0.158)	(0.044)	(0.013)
X_{OO}	1.971	0.002	-0.010
	(1.986)	(0.035)	(0.011)
X_{FC}	-0.165		-0.057**
	(0.12)		(0.028)
X_{OC}	-0.014	0.031	-0.080***
	(0.334)	(0.071)	(0.01)
SFP	0.519*	0.284***	0.017
	(0.306)	(0.105)	(0.013)
SIZE	-1.383	-16.664	-11.249**
	(9.614)	(10.513)	(4.718)
FAMLAB	-16.619	-49.949	-148.380***
	(75.689)	(44.21)	(29.749)
FIXASS	3.701	5.525	40.090***
	(11.315)	(13.319)	(6.284)
ANIMALD	-7.626	50.313***	10.022***
	(22.161)	(15.219)	(2.559)
RENTPROP	15.194	-147.330**	-168.624***
	(96.804)	(62.922)	(24.307)
λ	0.430***		
	(0.084)		

Notes to table: SE in parenthesis. ***, ** and * indicate statistical significance at 1%, 5%, and 10% levels respectively. λ is the spatial parameters in the equation 3.

[6] For the SAR model the coefficients are not directly interpretable. Instead the computation of partial derivatives is necessary, differently from the SEM case. However, for the purpose of model comparison, it is sufficient to look at the actual estimates. The estimates of the direct, indirect, and total effects are available upon request.

[7] Again, primarily because the SEM model is the only one allowing the direct interpretation of the estimated parameters.

the same regime are limited. In general, the estimated coefficients related to productivities are more significant in the *historical* regime compared to the *regional* regime.

We get similar results estimating the coefficients for the control variables, with overall evidence of a better fit in the case of the *historical* and *hybrid* models compared to the *regional* model. All the coefficients show the expected sign and, with few exceptions, these are also consistent across regimes, although they vary in magnitude, as expected.

The most interesting result concerns the capitalisation rates, estimated at 52%, 28% and 2% in case the MSs adopted the regional, the hybrid, or the historical model, respectively. The estimated value in the case of MSs adopting the historical model is, however, not statistically different from zero. In the case of the hybrid model, we get a very significant result, and in the case of the regional model, the null hypothesis is rejected at the 10% significance level in a standard two-tail test. Considering that the capitalisation rate can only be larger than zero, a one-tail test may also be appropriate, and this would reject the null hypothesis at a lower significance level (5%).

5. DISCUSSION AND CONCLUSION

In 2013, the CAP reform marked an important step toward the convergence in the level of farm support across the different territories of the EU. The last reform, like the previous ones, has generated a vigorous debate about the possible impact of farm payments on input prices, and in particular on farmland rents. Payments decoupled from production and attached to land increase, in fact, the possibility of capitalisation, a side effect which should be taken into account when planning the redistribution of farm support.

The existing empirical literature on the capitalisation of agricultural subsidies in farmland rents in Europe consistently reports evidence of capitalisation, but the estimated rate varies widely across studies. The geographical coverage of the studies, usually narrow (one region), is among the reasons of such heterogeneity, together with the regime adopted by the reference MS for the 2003 reform for introducing the SFP. This type of payments is, in fact, intrinsically related to land, and this condition is expected to increase the rate of capitalisation compared to coupled subsidies. The extent of the phenomenon is however related to contextual factors such as land market imperfections (Ciaian and Swinnen, 2006) and the availability of entitlements compared to eligible hectares (Ciaian, Kancs, and Swinnen, 2008). Most importantly, the implementation regime could have influenced the rate of capitalisation (Kilian and Salhofer, 2008; Kilian et al., 2012) in the context of the 2003 reform. The three schemes available to implement the 2003 reform differ from each other regarding the perspective harmonisation. Almost all the MSs applying the regional model are NMS and, due to their recent admission to the EU, the regional scheme with harmonised payments was for them the first and unique scheme of payment adopted. Only a few MSs experienced a direct transition from the coupled payments to a decoupled payment scheme with harmonised payments across farms, while many MS preferred to link the level of decoupled payments to the historical coupled payments. Following the 2013 reform, these Ms are experiencing a process of gradual harmonisation of payments. Some other MS chose the hybrid model that implemented some partial harmonisation of payments during the years preceding the 2013 reform. The regional regime, which foresees an equal payment per hectare among farmers, may have facilitated the capitalisation and the leakage of subsidies out of the agricultural sector. Now that the 2013 reform is being implemented a further step in the direction of payment harmonisation is made (Ciaian, Kancs, & Swinnen, 2014). Thus, understanding the extent to which the harmonisation is responsible for higher capitalisation becomes even more relevant.

This work frames into this stream of theoretical and empirical debate about the influence of the implementation regime on agricultural payment capitalisation. We estimate the capitalisation rate using regional aggregate data from countries that adopted different implementation regimes and show how the estimated capitalisation varies across regimes. Consistently with the previous theoretical analysis, we find cross-sectional evidence of structural heterogeneity in the capitalisation rate among regions from member states that implemented the historical, hybrid, and regional regimes. When estimation is conducted on the full sample of European regions, results suggest that 3 cents per additional Euro of payment get capitalised into the land price, which is quite a modest result compared to existing evidence: in Europe, the capitalisation rate of decoupled subsidies has been previously estimated at between 18 and 20 cents in NMS (Ciaian and Kancs, 2012); between 25 and 77 cents in Germany (Kilian et al., 2012); between 8 and 76 cents in Sweden (Nilsson and Johansson, 2013). When considering the implementation regimes separately, it is found that as much as 52 cents per Euro get capitalised into the land price in MS that adopted the regional regime. Only 28 cents per Euro are capitalised in MSs that adopted

the hybrid regime, and there is no evidence of capitalisation in MSs that adopted the historical regime.

These results add substantial evidence to the hypothesis that an equal payment for all farms in the same region is the scheme producing the highest capitalisation rate. The result is robust to the inclusion of other variables that drive farmland rents and to the use of econometric techniques that explicitly take the geographical position of the region and its neighbouring relationship into account. Unfortunately, the data source does not provide additional information about how the scheme has been implemented in each MS, and among regions in each MS. Thus, from the evidence in the study, it is not possible to infer any causal effect of the implementation scheme adoption on the capitalisation rate.

Based on our results, we conclude that in MSs that applied the historical model, the decoupled SFP did not capitalise into land prices, but, since these MSs are now experiencing the transition toward the full harmonisation of payments, the likelihood that this transition will bring the capitalisation of subsidies is very high. MSs that applied the hybrid scheme, in fact, already started the process of harmonisation and the payments have been capitalised since the very first years after the introduction of the SFP, although to a lower extent as compared to MSs that implemented the regional scheme.

Thus, in general, our results emphasise the role of policy design in determining a crucial outcome such as the capitalisation of agricultural subsidies in farmland prices. The application of a general policy objective, such as decoupling subsidies from production and attaching them to land, may lead to very different outcomes depending upon the implementation details. In the case of the CAP 2003 reform, the crucial elements of the policy design have been the rules governing the distribution of the payment entitlements and their linkage to the eligible hectares of agricultural land. This is of course extremely relevant for policymakers, in view of any further reform of the policy.

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Contribution of periurban farming systems to local food systems: a systemic innovation perspective

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Abstract. The debate on food security has highlighted the connection between periurban farming systems (PFS) and local food systems (LFS) for academic research. Several researchers have called for in-depth analysis of the participation and impact of farmers in LFS, and the systemic innovation perspective can provide relevant analysis of the sustainability of this agro-food system. The objective of the current study is to investigate the integration of PFS into LFS from the systemic innovation perspective, by analysing systemic failures and merits that hinder or promote the contribution of PFS to LFS for farmers and commercial actors. The case study is the LFS of the urban Pisa region in central Italy. Results show that farmers there are adapting to urban pressure, which improves the sustainability of their farming practices. At the same time, commercial actors have a commercial opportunity to include local farmers in their economic strategy. Nevertheless, individual initiatives must be coordinated to support the sustainability of both LFS and PFS. This study thus developed an innovative method to identify systemic failures and merits for farmers and commercial actors to address sustainability strategies at the territorial level.

Keywords: adaptation, urban sprawl, local food network, systemic failures, Italy.

1. INTRODUCTION

Agriculture currently faces several systemic challenges, such as volatility in commodity prices, climate change, obstacles in generational turnover, and increasing labour costs, all of which influence how agriculture produces food. The population growth expected in urban areas has raised serious concerns about the ability of agro-food systems to feed people in the near future (Fraser et al., 2005; Godfray and Garnett, 2014). According to the FAO (2010), periurban farming systems (PFS) throughout the world need to be involved directly in relocating food systems to respond to the new challenges of food security. Local food systems (LFS) thus appear central in addressing periurban farms' contribution to local food security, even in the Global North (Opitz et al., 2015).

The literature defines PFS in several ways: geographically, PFS are simply agriculture performed near urban areas (Filippini et al., 2018), while relationally, PFS are agriculture which has a functional relationship with an urban area (Nahmías and Le Caro, 2012). Several definitions lie between these two extremes. In this study, PFS are defined as farming systems near the main urban area of the case study, including territorial, production, social, and institutional factors.

LFS also appear as a systemic phenomenon, in which different actors at different territorial levels integrate themselves in a sustainable way (Kneafsey et al., 2013). Analysis of LFS is complicated by the lack of a single definition of LFS (Eriksen, 2013). In literature it has been defined as the emergence of high-quality and typical food (Arfini et al., 2019), social and organisational relationships among actors (Renting et al., 2003), a specific geographic area near consumers (Horst and Gaolach, 2015), or food supply that provides food to urban dwellers (Morgan, 2015; Wiskerke, 2009). This study defined a LFS as the food system by which periurban farmers can provide food to consumers of the periurban and urban area.

The systemic innovation (SI) perspective may help to identify innovation mechanisms in farming systems, since "systems approaches to innovation are essentially an attempt to think through and analyse the nature and implications of the collective character of innovation" (Edquist, 2002). Farms that follow this approach do not normally innovate in isolation, but in interaction with other organisations, which involves different sectors and different types of know-how, from production to consumption, from policy and institutions to firms and private agents, and from technical to social skills. Therefore, the SI perspective is relevant in this context. Some studies indicate that integrating PFS into LFS is a source of innovation in farming and food systems (Houdart et al., 2012; Paül and McKenzie, 2013). Other studies highlight the need for further analysis of the actors of these innovations, their relations, and the infrastructure in which they act (Bloom and Hinrichs, 2011; Filippini et al., 2016a, 2018; Venn et al., 2006; Watts et al., 2005).

From a farming system perspective, the literature has called for in-depth analysis of the participation of periurban farmers in LFS. Urban sprawl may influence farming practices and output (e.g. intensity, crop rotations) and thus farmers' ability to change or expand their local commercial strategies. According to the literature, understanding the PFS state "is a first step towards aligning agricultural and nutritional goals" (Morrison et al., 2011 p. 498) in the development of a more sustainable agro-food food system (Galli et al, 2020).

From a food-chain perspective, LFS studies have focused more on analysing individual initiatives than on adopting a systemic understanding of LFS at the territorial level (Bui et al., 2016; Lamine et al., 2019). Sonnino (2014) highlighted a lack of understanding of the "exchange nodes" in LFS networks, such as processors, wholesale markets, retailers, and others.

From a territorial perspective, LFS studies have not adequately captured the "inherent complexity of the place" (Duram and Oberholtzer, 2010). According to several researchers (Duram and Oberholtzer, 2010; Ilbery and Maye, 2006; Venn et al., 2006), LFS studies have focused mainly on relationships among actors who already participate in LFS, and less on the wider spatial and social dynamics of the place. This could be an obstacle for PFS studies, given the particular context in which periurban farmers work (Filippini et al, 2020).

The innovative process involved in integrating PFS and LFS thus requires further study to improve the sustainability of the innovation for both PFS and LFS. The aim of the study is to analyse the integration of PFS into LFS from an SI perspective, which identifies systemic merits and failures of the innovation for both systems. This is essential to develop scenarios of transition to new forms of sustainability for LFS and PFS. To our knowledge, this is the first time that SI has been applied at the territorial level to agro-food-system analysis. Adopting a systemic perspective of territorial innovation processes makes it possible to apply an interdisciplinary, multi-level, and multi-actor approach, which is necessary to respond to claims made in the literature.

The article is organised as follows. Section 2 explains the theoretical background of PFS adaptation and issues related to the connection with LFS. Section 3 describes the case study, the source of information and how SI was applied in the present study. Section 4 shows results of applying the SI perspective to periurban farmers' participation in LFS. Section 5 discusses insights of the study and the methodology in light of the current literature. Finally, the last section provides concluding remarks and offers ideas for future studies.

2. THEORETICAL BACKGROUND

2.1 Contribution of periurban farming systems to local food systems

PFS are characterized by specific environmental, economic, and social pressures (Tolron, 2001). In areas of urban sprawl, land-use change is rapid and results in agriculture competing for natural resources, such as water and land. Several land issues influence PFS crop-

ping systems, such as degradation of fertile land (EEA, 2006), fragmentation of agricultural areas, and the lack of access to land. Urban pressure increases the price of land, which results in land insecurity, for which the solution is shorter leases in anticipation of more profitable urbanisation, and in land abandonment and reforestation (Tolron, 2001). Several positive externalities of farming practices, such as flood control or ecosystem services, are limited, while negative externalities are exacerbated, such as production of noise or odours (Heimlich and Anderson, 2001). The agricultural economy and political representation become marginal in areas where agriculture's position traditionally predominated. New social conflicts result from the coexistence of different community interests and activities in the same area, and at the same time farmers face new expectations for farming systems and new and varied demands from the urban system (Darly and Torre, 2013; Heimlich and Barnard, 1992; Henderson, 2005).

In this situation, farming systems may adapt to a particular territorial context that is characterised by continuous change. The literature mentions adaptability as one of the attributes of sustainable farming systems (López-Ridaura et al., 2005). Adaptability is also identified as a main characteristic of PFS (Clark et al., 2007; Soulard et al., 2017; Tolron, 2001). Clark et al. (2007) described the "pattern of adaptation" of PFS as changes in the cropping system as well as on-farm diversification. Periurban farmers must adapt their cropping systems to spaces into which a complex urban environment encroaches. Adaptation requires changing the intensity of production, as well as increasing or decreasing certain types of production (Diaz-Ambrona and Maletta, 2014; Filippini et al., 2016b; Wortman and Lovell, 2013). All of this occurs in a context that includes an uncertain future threatened by climate change and land insecurity (Diaz-Ambrona and Maletta, 2014; Wortman and Lovell, 2013). On-farm diversification entails changing a farm's structure to an urban-oriented context to meet urban expectations and demands for food production and services, as well as to minimise conflicts with urban neighbours. This adaptation helps to maintain agriculture in periurban areas. Based on the literature, recognising the multi-functional character of PFS has promoted several agriculture services, such as the development of short food-supply chains and/or social and educational farming, as a way to maintain agriculture in periurban areas (Filippini et al., 2020; Zasada, 2011). By definition, PFS are adaptive farming systems which tend to be heterogeneous: different farming strategies are implemented, which reflects that agriculture has multiple responses to the demands of nearby urban areas (Soulard et al., 2017). Moreover, heterogeneity occurs within each PFS: empirical analysis has observed that farms tend to combine the commercial strategies of local and non-local food chains (Filippini et al., 2016a). In addition, farms may adapt their practices to urban pressure, but not their commercial strategies (Filippini et al., 2016a), especially when conventional markets are more convenient (Brunori et al., 2016; Touzard et al., 2016).

According to the literature, PFS should be more prone to participate in LFS, as proximity increases access to local urban markets and market niches (Jarosz, 2008), decreases transaction costs due to more direct social contact between producers and consumers, and decreases distribution and transportation costs (Holloway et al., 2007). More generally, periurban agriculture is perceived as an innovative context that promotes the development of LFS (RUAF, 2008). Participating in LFS is seen as a form of innovation and "smart agriculture" (Corsi et al., 2021) Empirical studies have shown that commercialisation is one of the few factors involved in adapting to urban pressure in French periurban areas (Houdart et al., 2012). However, few researchers temper the positive role of periurbanisation in the emergence and development of LFS. The locally grown high-quality food that consumers demand requires more labour and investment in diversification, which increases production costs, and requires more available land, which is hindered by the same process of periurbanisation (Jarosz, 2008). Paül and McKenzie (2013: 94) even argue that short food supply chains in periurban areas "are only possible if farmland preservation is guaranteed, and that the former does not come as a direct consequence of the latter". Farmers may experience issues when adapting to urban pressure and demands, such as discovering that adaptation is not attractive or that they do not adapt effectively. One potential response is to simply move their agricultural activities, given the income that selling periurban land guarantees, and stop farming in periurban areas (Pascucci, 2007). Thus, the adaptability of PFS to LFS should be not taken for granted.

Similarly, if farmers do not produce locally, the economic actors who contribute to the value chain, such as small butcheries, slaughterhouses, and groceries, may also face a crisis, which could decrease the sustainability of LFS (Filippini et al., 2020). To date, few studies have focused on the processors and commercial actors who interact with farmers in LFS. According to Bloom and Hinrichs (2011), studies underestimate the contribution of local actors in the traditional conventional value chain to the development of a reliable LFS. Their analysis criticised the frustration of urban retailers and distributors when making direct commercial agreements with farmers

who participate in LFS, even though the participation of these actors can help scale up the LFS and thus improve the local food economy, which is the ultimate purpose of the LFS movement. According to Sonnino (2014), a more effective connection between urban and rural areas in LFS requires understanding the role of distributors in the value chain, who connect farmers to consumers, as well as the role of coordination and governance of LFS.

2.2 Application of the systemic innovation perspective to the contribution of farming systems to LFS

According to Knickel et al. (2009), the gap between the need for change and farmers' willingness to adapt exists because innovation policies and research have applied a linear approach from innovators to farming and thus have failed to address the relevant issues in farming systems that influence sustainable innovation. Doing so requires a more systemic approach to innovation that extends beyond the farmer who applies the innovation, to involve many interrelated actors for whom innovation has a performative character: "supermarkets that introduce self-service tools for fruit and vegetables reconfigure the roles between consumers and retailers' personnel, and imply learning processes of all the involved actors. Retailers also play a key role in shaping production systems, as they are able to impose their standards on national production systems" (Knickel et al., 2009: 138). Researchers define the inclusive character of systemic approaches as a "co-evolutionary process", as it requires "combined technological, social, economic and institutional change" (Klerkx et al., 2012). In this approach, innovation is perceived as a process characterised by continuous feedback mechanisms and interactive relations among the actors within the framework of specific institutional rules. Consequently, innovation is an evolutionary process that always changes and adapts itself, and is not based on the concept of optimality (Edquist, 2002). Innovation implies a complex system of strategies, organisation, and hybrid networks that extends beyond the use of new technology or the definition of a new process (Knickel et al., 2009).

When applying a systemic perspective, those who research farming systems recommend a multi-actor, multi-level, and inter-/trans-disciplinary approach, due to its inclusive characteristics (Klerkx et al., 2012). Multi-level implies including different elements at the same scale, while multi-scale considers them at different scales (Cash et al., 2006). Inter-/trans-disciplinary is the progressive integration of different disciplines and sectors, such as academia and actor experts (Vandermeulen and Van Huylenbroeck, 2008).

In farming systems analysis, Lamprinopoulou et al. (2014) and Kebebe et al. (2015) applied a specific SI perspective that identifies SI structures and functions, based on contributions of Woolthuis et al. (2005), Wieczorek and Hekkert (2012), Edquist (2001), and Weber and Roharacher (2012). The objective was to evaluate the policies that sustain technological innovation to identify the specific failures that hinder innovation.

Wieczorek and Hekkert (2012) used an SI structural-functional analysis to determine SI structures and functions. SI structures are the elements that drive the innovation: actors, interactions, infrastructure, and institutions. The actors are the agents of the innovation, and the innovation process emerges from their interactions. They move in a particular infrastructure which includes physical (e.g. roads and territorial elements), financial, and knowledge infrastructures. The institutions are the written or unwritten rules which the actors should respect. SI functions are the processes that enable the innovation to perform well. Weber and Rohracher (2012) define systemic functions as the "basic 'activities' or key processes required for successful system growth and performance of the innovation system". Researchers have identified several types of functions, depending on the case study and purpose of the study: knowledge diffusion, market creation, network exchanges which function at the micro-level, reflexivity, directionality, and policy coordination at the macro-level to effect transformations (Lamprinopoulou et al., 2014). Analysis of systemic functions complements a structural focus as it is process-oriented: structures make functions meaningful and vice versa, which supports the concept that a structural element must always be changed for policies to enable or strengthen functions. According to Lamprinopoulou et al. (2014) "an integrated structural-functional analysis provides a much more comprehensive overview of the operation of systems and the determinants that shape innovation trajectories". In this framework, "systemic failures" – also called systemic problems or blocking mechanisms (Wieczorek and Hekkert, 2012) – are obstacles that hinder development of innovation. According to Lamprinopoulou et al. (2014), identifying failures helps to identify "systemic merits" and thus instances when SI functions are working well and driving effective innovation processes.

The literature has focused especially on mapping structures and functions and identifying systemic failures in order to provide policymakers with a list of measures to fix problems and highlight positive aspects of the system (Wieczorek and Hekkert, 2012). To date, this approach has rarely been applied to farming systems or the agricultural sector. For example, Kebebe et

al. (2015) applied structural-functional analysis to small dairy farmers and concluded that systemic failures in developing innovation were related mainly to missing actors, limited capacity of existing actors, inadequate infrastructure, limited interactions between actors, infrastructure failures related to property rights, and bureaucratic processes and corruption, which hinder the development of innovation among smallholders. Lamprinopoulou et al. (2014) developed a comprehensive structural-functional systemic framework of analysis to compare national agro-food systems in Europe and identified differences in actors' skills and in infrastructure, which identified policies to support the agricultural sector. Thus, analysing application of this framework to a specific case study should provide new insights into the approach and help to develop effective policies at the territorial level.

3. MATERIALS AND METHODS: HOW TO UNDERSTAND THE CONNECTION BETWEEN PERIURBAN FARMING SYSTEM AND LOCAL FOOD SYSTEM PFS AND LFS FROM AN SI PERSPECTIVE

3.1 Case study

The case study is the periurban region of Pisa, a medium-sized city of 86,000 inhabitants in Tuscany, central Italy (Fig. 1). The area consists of six municipalities that were associated until 2020 in the Area Pisana inter-municipality. The area includes the coastal plain of the Arno River and a hilly area known as Monte Pisano (917 m a.s.l.). Thus, it is geographically defined by the sea to the west and the hills and mountain to the north and north-east. The area includes a regional natural park that contains privately owned agricultural land. The area is also representative of urban sprawl: the population in

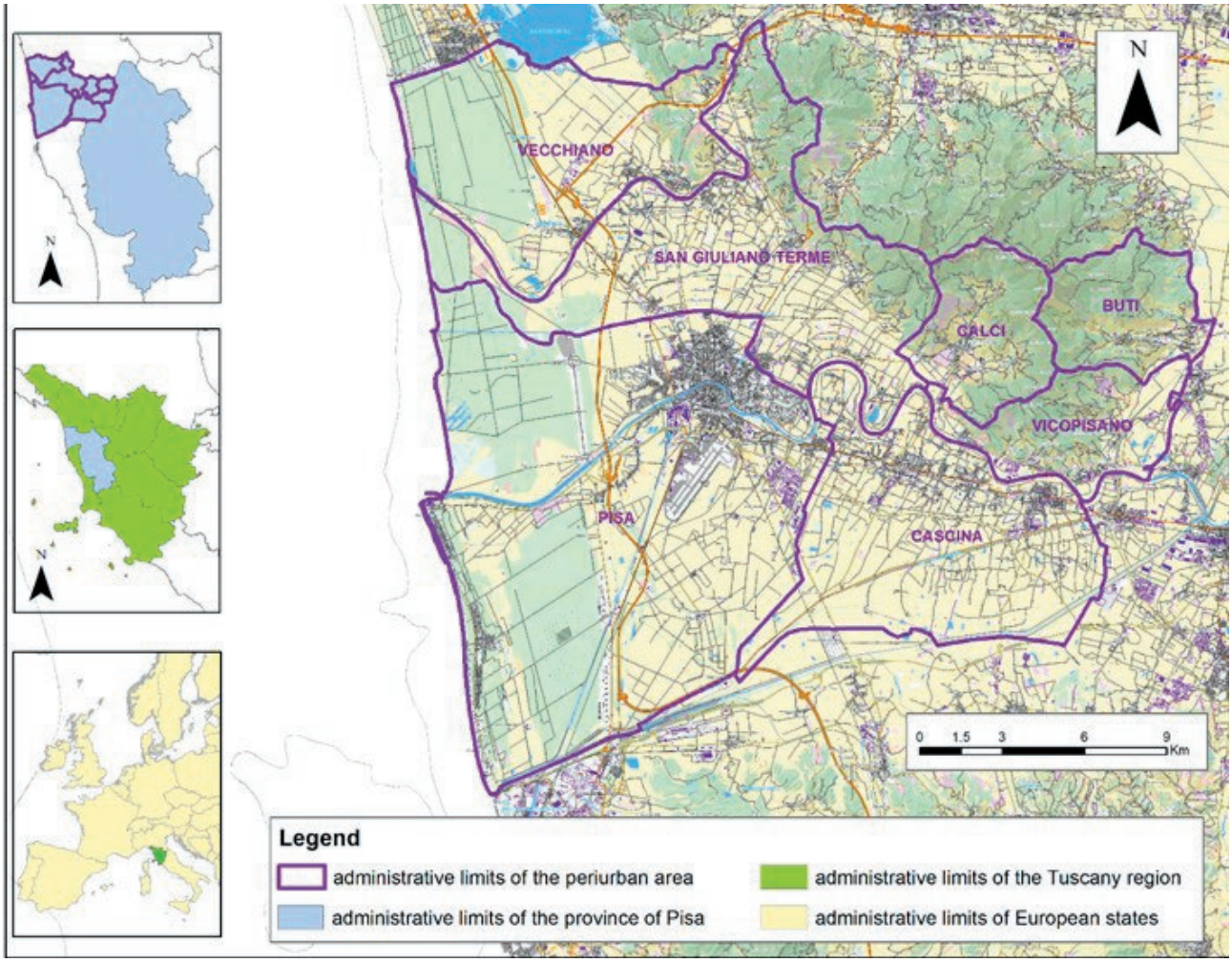

Figure 1. Case study: the periurban area of Pisa (Source: Filippini et al., 2020).

the main urban centre of Pisa has decreased since the 1980s but has increased in the nearby small towns. The geographic borders have created a unique social identity unlike those of nearby areas. Farming systems in the area seem to differ from others in the Province of Pisa: agriculture is not specialised or specific to one food chain, mixed farming systems still persist, and farmers rely on several types of commercial organisation (Filippini et al., 2016a). These characteristics have helped researchers consider different types of primary production. Previous research has shown that LFS management is one of the most challenging issues in the area, as acknowledged by farmers and institutional actors (Marraccini et al., 2013). Farming systems in the area have followed the main trend of Mediterranean agriculture: the number of farms decreased from 1990-2010 (-56%), especially for vegetables (-92%), while mean farm size increased slightly (Marraccini et al., 2012).

3.2 Interdisciplinary, multi-level, and multi-actor approach: selection and analysis of the sample

The method is based on an interdisciplinary, multi-actor, and multi-level approach (Vandermeulen and Van Huylenbroeck, 2008; Klerkx et al., 2012; Cash et al., 2006) (Fig. 2). The study is based on integrating multiple disciplines, especially agronomy, economics, and geography. As it is focused on understanding the integration of PFS into LFS, it is first based on analysing farms and farming systems, given the production and commercialisation conditions of farms in the periurban area. Then, the study analyses the relationships between the PFS and the rest of the local agro-food system (i.e. the LFS) by interviewing commercial actors. A multi-level approach is applied in the study, first by analysing farming systems and then by extending it to a more territorial basis, especially the value-chain actors in the LFS. Analysing relationships between PFS and LFS provides a multi-actor perspective that considered both farmers and the first buyers of local agricultural products, such as processors and retailers, as well as the intermediate actors who aim to help organise the LFS.

The analysis is based mainly on interviews with farmers and then with the LFS's first buyers in 2014-2015. As the analysis did not include perspectives from consumers or institutions, the overall LFS was not considered (Fig. 2). Farms were selected to represent the territorial farming system of the periurban area of Pisa as described in ISTAT (2010). Three criteria were used to select the farms: the main types of production, farm size, and the distance from the farmstead to the urban centre. The initial sample contained 58 farms oriented to types of production that represented the territorial farming system: extensive crops (65%), livestock (14%), vegetables (13%), and olive groves (8%). Farmers were contacted directly in order to conduct semi-structured face-to-face interviews in their farm's head office. Interviews focused on the farming territory, crop management, farm management, land-use intensity, commercialisation, the farmer's individual characteristics, the main type of production, and commercialisation constraints.

Based on these interviews, 19 commercial and intermediate actors were selected, the first buyers of farmers' products (e.g. processors, groceries, supermarkets, farmers' markets) and the intermediate actors who interacted with farmers. The processors included two cheese factories, one slaughterhouse, one butchery, three olive mills,

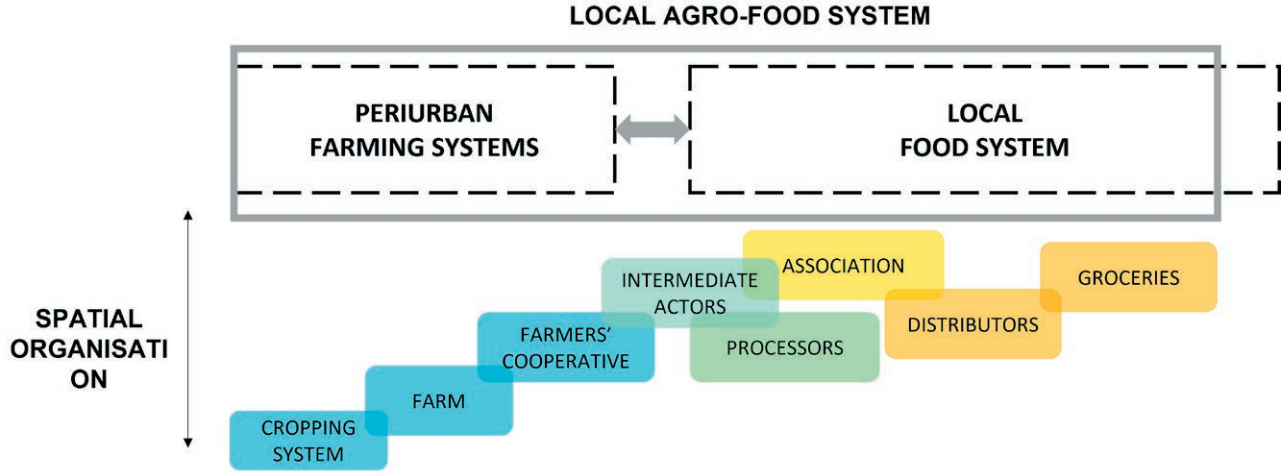

Figure 2. Multi-level and multi-actor approach: elements of the local agro-food system.

one wheat mill, and one general processor (mainly vegetables). The interviews also included three supermarkets, four groceries, and the coordinator of a farmers' market. One farmers' cooperative and a local livestock association were included as intermediate actors. Interviews with the commercial actors included questions about their practices, the importance of local farming systems for their income and stock of products, and limitations of and opportunities for interacting with local farming systems.

Previous studies have observed that only 26 of the 58 farms in the sample participated in the LFS: 19% of them sold all production to the LFS, 65% maintained hybrid commercialisation between those of the LFS and non-LFS, and 15% sold less than 10% of their products to the LFS (Filippini et al., 2016a). Qualitative textual analysis of the interviews was performed to compare the actors' viewpoints.

3.3 Application of the SI perspective

To define the contribution of PFS to LFS in the context of SI, SI structures and functions must be defined according to the literature. First, components of SI structure in the connection between PFS and LFS were identified: actors, interactions, infrastructure, and institutions (Table 1). The actors were the farmers and other actors, and their interactions took place in the LFS. The infrastructure was the periurban area, which was defined according to geography (i.e. physical proximity to the urban area) and relations and organisations (i.e. a common background of action for actors). Farmers were related because they shared the same production constraints. Farmers and commercial actors were related because they shared the same interest in developing a LFS based on proximal relationships. Political actors shared similar concerns as the other actors about territorial management and the creation of an urban food system. The institutions were the municipal, regional, and national rules which govern food production and the participation of farmers in the LFS.

Table 1. The structures of systemic innovation in this study.

Actors	Farmers, processors, supermarkets, groceries, intermediate actors
Interactions	Commercial relationships in local food systems
Infrastructure	Periurban area
Institutions	Municipal, regional, and national rules

SI functions are the dynamics that enabled innovation to perform well. Among the functions identified in the literature, the market, networks, directionality, and policy coordination were selected to be evaluated in this study. The literature provides several lists of systemic failures. Wieczorek and Hekkert (2012) developed a list of "systemic problems" related to the four structures as a function of their presence and quality/effectiveness. Lamprinopoulou et al. (2014) and Weber and Rohracher (2012) identified several failures in the literature and adapted them to the characteristics of their case studies. Based on the literature, a variety of systemic failures was thus chosen (Table 2). According to Lamprinopoulou et al. (2014), systemic merits are identified directly by identifying specific opportunities and qualities of the same categories of the structures and functions identified. In other words, identifying the failures makes it possible to identify merits. Thus, merits were also identified for each systemic failure.

Table 2. Description of the systemic failures selected from the literature.

Systemic Failure	Definition	References
Actor problems	Absence of actors and/or lack of skills	Wieczorek and Hekkert, (2012)
Institutional failures	Missing or malfunctioning of written or unwritten rules, which hinders innovation	Lamprinopoulou et al., (2014)
Infrastructural failures	Absence of physical, financial, and/or knowledge infrastructure	Lamprinopoulou et al., (2014); Wieczorek and Hekkert, (2012)
Interactions or network failures	Networks of actors are too dense; actors do not interact enough	Lamprinopoulou et al., (2014); Weber and Rohracher, (2012)
Market structure failures	Imperfections in the markets or monopolies; unbalanced market power; information asymmetries	Lamprinopoulou et al., (2014); Weber and Rohracher, (2012)
Directionality failures	Lack of shared vision, and inability for collective coordination of fragmented agents of change	Lamprinopoulou et al., (2014)
Policy coordination failures	Lack of consistency among policies at different institutional levels (national vs. local) and among different sectors	Lamprinopoulou et al., (2014)

4. RESULTS: A STRUCTURAL-FUNCTIONAL ANALYSIS TO UNDERSTAND SYSTEM INNOVATION

Based on the interviews, the farmers' and commercial actors' opinions on systemic failures and merits of their participation in the LFS were summarised (Table 3).

4.1 Actor problems/failures and merits

According to farmers, the blocking mechanisms of the systems were related to whether participation in LFS requires them to develop specific know-how, such as the ability to sell directly to consumers and other small businesses, while most farmers usually sold their products to cooperatives or wholesale markets. Some farmers indicated that another failure of integrating PFS into LFS was the need to address conflicts with urban residents who do not understand the daily work on farms, which produces noise, smell, etc. From the farmers' perspective, it seemed contradictory that consumers want local food but seem to have difficulty understanding how agriculture works.

Among the actors' merits, farmers considered that the presence of other people in the farm structure, who can help with sales or processing, was a driver for

Table 3. The most important systemic failures and merits of systemic structures and functions according to farmers and commercial actors in the periurban region of Pisa (Italy).

Systemic structure and function	According to	Failures/Problems/Blocking mechanism	Merits/Opportunities
Actor	Farmers	Need for specific know-how and manpower; conflicts with neighbours	Presence of family and structure
	Commercial actors	Not enough farmers; problems with the quality of the product: season, diversification, packaging; lack of awareness of local agriculture and farmers	Local food supply meets consumers' demands for local products
Institution	Farmers	Rules for diversifying the product; manpower; territorial management; lack of dialogue	
	Commercial actors	The same rules for small and large businesses	
Infrastructure	Farmers	Fragmentation of areas; production constraints; funding; knowledge	Proximity to urban consumers, proximity to crop storage
	Commercial actors		Greater potential to reach and contact farmers in order to control and trace production
Interactions, networks	Farmers	Individual efforts to participate in local food systems; no network among farmers	Multiple diversified networks that diversify the risk; flexibility in responding to commercial actors' demands
	Commercial actors	Strategy of contacting the same farmers already involved in other networks; short-term organisation	
Market structure	Farmers	Difficulty in being paid by small business; no markets for certain products	Market power; high demand for local food; paid immediately by final consumers; not always possible to predict and manage final consumers' demands
	Commercial actors	Information asymmetries; difficulties in negotiating the supply with farmers and with supermarkets for processors; consumer preferences for certain products change and do not reflect local traditional products	High demand for local food
Directionality	Farmers	Short-term participation in commercial actors' businesses; lack of shared and territorial vision	
	Commercial actors	Differing private visions that may compete with each other	Organising long-term food-chain projects to maintain shared visions
Policy coordination	Farmers	Different interpretations of rules among institutions	
	Commercial actors	No coordination of private initiatives; lack of policies that promote local products	

developing a LFS. The LFS was also considered a way to increase family income. In this case, the LFS was seen as a way to diversify farm income by processing the primary products and/or developing space to sell. Here, the farm family had great relevance: employing family members provides more flexibility in organising activities and costs less than hiring people. This was especially relevant when farmers perceived the LFS as a risky and unsure market.

According to processors, groceries, and supermarkets, the greatest system failure was the lack of local farms, but it has different meanings for each of them. According to groceries and supermarkets, few farmers from whom to purchase products were available. In particular, they expressed a lack of knowledge about new farmers who could be included in the LFS and an inability to contact farmers. During the interviews, some retailers even asked researchers to provide the names of farmers who could sell their products. Their usual strategy was to contact farmers who already participated in other LFS initiatives. Some of these retailers did not seem to know about characteristics of the farming systems in the area. They were surprised when researchers showed them data on the decrease in horticulture production, which they considered as a typical farming system in the area.

This was not the case for processors, who seemed familiar with local farming systems and their potential production, to the extent that they recognised the production capacity of each farmer. This was likely because such small-to-medium processors had worked in the area for a long time and had seen the farming system change, while some retailers were younger and less experienced. To processors, the lack of available local farms was due to the crisis of local farming and the decreased amount of agriculture, and thus primary production in the area, which influenced the economy.

Retailers, especially small businesses, highlighted the lack of diversified products offered, since most farmers provided the same seasonal fresh food, but few processed products. Processors of fresh vegetables complained about the difficulty in verifying the quality of products, as vegetables may arrive without being properly cleaned or packaged. Nevertheless, for both types of actors, the presence of local farms that participated in the LFS was a merit of the system. Consumers today increasingly want local food, and local farming systems are a source, which generates more business.

4.2 Institutional failures and merits

Institutional failures included the presence or absence of regulations that hinder the contribution of PFS to LFS. Most farmers experienced limitations related to regulations for processing primary products and the on-farm direct sale, including cheese from dairy production and jam and juices from fruits. According to farmers, the obstacles were related to meeting health regulations, as a large amount of money is necessary to convert the working environment. Several farmers mentioned the lack of rules adapted to small farming businesses. Other rules were related to the natural park in the production area: although it protects the use of land for agriculture, it also imposes strict environmental rules, which limits farm diversification. For example, to process sheep milk on the farm for direct sales, a farmer had to obtain permission from the local municipality, the local health authority, and the regional natural park, and each one imposed different and contrasting rules. The local health authority imposed strict health requirements for farm buildings according to European Union (EU) regulations, while the regional natural park, whose main interest is to preserve nature in the territory, had refused permission for several years because on-farm processing could impact the natural equilibrium of the area. Rules that influence diversification also influenced the involvement of seasonal workers. Regulatory constraints included a large amount of bureaucracy and the time required for such investments. Regulation failures for the small processors and retailers were related to the lack of regulations that are flexible and adapted to small businesses, because the same rules were applied to small and large businesses.

4.3 Infrastructure failures and merits

The infrastructure of the periurban area has both failures and merits for the contribution of PFS to LFS for farmers (Table 2). The infrastructure failures included both physical and knowledge failures. Physical infrastructure failures were related to urbanisation, which fragments the land and may influence crop rotations. Increased transportation costs and the use of infrastructure caused farmers to stop growing irrigated crops far from the farmstead. The presence of infrastructure and fragmented agricultural area influenced the ability to graze land and rotate the grazing due to the difficulty in moving animals. Knowledge failures were related in particular to information about financial opportunities that was fragmented among the many levels of institutions, from the region to the farmers' union that helps farmers to request funds from the EU. Another blocking mechanism was related to combining Common Agricultural Policy (CAP) funds and bank loans, for example to invest in innovation of the farm's structure and process-

es. The guarantee of obtaining CAP funds is not always sufficient for banks to loan money to farmers, which further slows the innovation process.

Among the merits, farming in a periurban area was one of the most important factors that allowed farmers to develop short food-supply chains. As stated in the interviews, the proximity to urban consumers drove innovation for several farmers, even those who sold less than 10% to the LFS. The innovation passed through the diversification of production and/or farming functions to sustain the farm economy. Despite the uncertainties, which prompted farmers to maintain global food chains, the proximity to the urban area encouraged farmers to try some initiatives for specific products that were easier to sell to the LFS. Proximity to an urban area also means proximity to crop storage for crops that are not sold locally. Crops are usually stored near urban or periurban areas, as these areas are better connected to regional and national roads.

Commercial actors also mentioned the merits of the infrastructure. For both processors and retailers, the proximity to farmers decreased transportation costs because the farmers were nearby, and because periurban farmers were usually better connected to roads than farmers in marginal rural areas. When farmers are closer and more reachable, it is easier to remain in contact with them and monitor their products for final consumers, which provides an advantage for marketing and thus income.

4.4 Interaction or Network failures and merits

The first network failure for farmers was that each farmer organised individual networks without coordinating his/her actions with other farmers or commercial actors. Farmers thus invested much individual effort in developing each network. Few farmers had established a farmers' network in the area. One farmer, in addition to processing grain and selling bakery products on the farm, opened a shop in the city to sell products from other periurban farmers. In the interview, he explicitly affirmed his intention to establish a famers' network initiative to promote the individual efforts of farmers. Farmers in the sample did not even mention other farmers' initiatives. Another farmer organised direct on-farm sales of vegetables with another farmer, who provided what he did not produce himself, and vice versa. This mutual exchange of goods diversified the products offered to consumers.

Conversely, a merit of this individual-based LFS network was that it enabled farmers to be more flexible in organising networks and adapting their commercial strategies to the variety of opportunities and demands of processors and commercial actors. For example, one dairy producer mainly in conventional food networks sold some of his milk to the local sheep milk processor when shortages of sheep milk occurred in winter. Another merit was that these individual networks allowed farms to diversify the economic risk of the LFS that they still perceived, as they can rely on several actors. From the viewpoint of commercial actors, especially retailers, however, this was a huge network failure. Since farmers were in contact with other commercial actors, they had less interest in investing in a relationship with a specific grocery and provided products only with short-term perspective. Moreover, the difficulty in including other farmers made the LFS a closed network.

4.5 Market structure failures and merits

One main market failure for farmers was that certain products, such as meat from dairy farming, fodder, other crops (e.g. winter wheat), and organic goat meat, had no local markets and needed to be marketed outside the local area. Farmers maintained conventional food chains for these products, but with less profit. Farmers also highlighted the difficulty in being paid by local commercial actors, especially restaurants, small groceries, and supermarkets. Providing local farm products to supermarkets seemed possible only when products were collected and organised by an intermediary actor. One unique LFS initiative identified in the case study sample was the "Carne Bovina di Pisa" a private meat label promoted by the local livestock producers' association, which is organised as a non-profit organisation by the local livestock association to add value to local livestock production. From the viewpoint of supermarkets, the intermediation by the association allows cows to be monitored and traced, and it organises the supply effectively. From the farmers' viewpoint, the association increases their bargaining power, which results in higher prices and guarantees that products are easier to sell in supermarkets.

Another market failure was the uncertainty some farmers expressed about the ability to sell all their products via direct on-farm sales and farmers' markets. This may have been due to the difficulty in predicting and managing expectations of final consumers, especially those who were not well known. For farms located further from urban centres, direct on-farm sales depend on the flow of people on roads, which may be less frequent. In these cases, farms maintain conventional food chains to sell the remaining products. Farmers stated that a major merit of the LFS was that final consumers paid

them immediately, unlike when they sold products to a cooperative or wholesale market that belonged to global food chains.

Market failures for commercial actors depended mainly on network failures, which cause market failures, as when few farms participate in multiple LFS, each one can provide only a small amount of product, or the frequency of production is highly irregular. Consequently, commercial actors, especially retailers, mentioned difficulty in negotiating contracts with farms. Thus, farmers in this case study seemed to have the market power in the LFS, deciding how much, when, and to whom to sell their products. This market power resulted from another market failure: information asymmetries between retailers and farmers (i.e. a lack of information about the farmers who can participate in LFS).

Another difficulty for small processors was organising supply to supermarkets. LFS products were usually distributed by the same processor who negotiated the supply to all supermarkets. Small processors were also concerned about consumers' expectations and preferences for a product; for example, fresh cheese was increasingly sought after, but it is not a typical product in the area. A high demand for local products was the main market merit for commercial actors. The certainty that consumers are sensitive to local food for its higher quality, traceability, lower environmental impacts, and ability to sustain the local economy was a strong driver for commercial actors to invest in LFS relationships. The PFS provided retailers and supermarkets with an advantage with consumers for developing new markets.

4.6 Directionality failures and merits

Directionality failures referred to the lack of a shared vision about the future of the local agro-food system.

Farmers recognized a lack of shared vision because they organised individual initiatives and because there was little recognition of their diversity and complementarity. There was also almost no recognition of the potential for sustainable and long-term integration with other food-chain actors. Farmers who sold products to groceries and supermarkets considered their participation in the LFS as temporary. Their objective was to be known by final consumers through retailers, restaurants, and other sellers to attract consumers to direct on-farm sales, which generate higher profits. Conversely, retailers tried to organise networks with local farmers to develop new markets for their own activities. Their directionality merit was that they envisioned a long-term economic strategy based on including local farmers who are invested in LFS opportunities as a long-term business strategy.

For processors, the slaughterhouse was an interesting example, as it had to interact with multiple actors (e.g. farmers, butchers, supermarkets) and their multiple strategies to manage their contracts and relationships. Consequently, the slaughterhouse actor interviewed perceived the slaughterhouse as a potential central node for coordinating individual initiatives, such as a territorial food-chain project. In this sense, an upstream example in the case study was "Campagna Amica", which is a national initiative that organises farmers' markets for members of the farmer's union. The local headquarters of the union decided to organise the market differently. The manager of the farmers' market allocated farmers among the markets in the area to regulate the products they supplied at the territorial level. This united the farmers in a single vision at the territorial level - the sustainability of local production - as farmers can sell only their own products. Similarly, the "Carne Bovina di Pisa" label united farmers, slaughterhouses, and supermarkets in a common vision of protecting local livestock production. Although these initiatives are initial attempts to promote individual efforts in a single vision, they include different shared visions which sometimes compete. In addition, the private nature of these initiatives drives the interests in specific directions, and sometimes lacks a systemic and territorial perspective.

4.7 Policy coordination failures and merits

For policy coordination, farmers mentioned public institutions which interpreted rules differently. The lack of dialogue among policy-makers resulted in rules that sometimes differed or overlapped, which indicated that policy-makers did not sufficiently address the innovations of farmers. There is a need for policy coordination and innovative public policies that can create a shared vision of the agro-food system. For example, several actors mentioned the lack of policies that promoted local products, such as farmers' markets or local labels which could highlight the specific connection between PFS and LFS. Public initiatives are needed in the area. For example, the province and the University of Pisa organised the "Piano del Cibo della provincia di Pisa", which aimed to encourage local dialogue to sustain LFS; however, the project ended when the local public administration changed. Other initiatives have been developed, but a gap remains for including local farmers.

5. DISCUSSION

The novelty of this study is the first application of the SI structural-functional approach to territorial analysis, especially for PFS that contribute to LFS. The study thus had an analytical objective: SI was used to envi-

sion innovation at the territorial level. The interviews with farmers and commercial actors identified relations between systemic failures and merits. By identifying factors that hinder development of innovation between PFS and LFS, it enabled actions, policies, and systemic measures to be identified that can solve the problems and highlight the positive drivers in the system (Wieczorek and Hekkert, 2012).

Results show that the systemic failures and merits expressed by periurban farmers and commercial actors are complementary, e.g. commercial actors' demands for diversified products and farmers' difficulty in investing in on-farm processing to diversify the supply. Thus, farmers and commercial actors have common visions of the potential future development of LFS, such as including processors to give farmers the opportunity to diversify the supply, specific policies that support group processing of farmers' products, and investing in new crops and products to diversify the local supply.

Actors seem to agree on the lack of merits of institutions, whose rules are perceived as just another cost. Actors also perceive a lack of policy coordination, especially when too many rules exist or seem to overlap, and require managing a large amount of bureaucracy. This is probably due to the lack of dialogue with public institutions, including local ones, which was indicated by previous analysis performed in the area (Lardon et al., 2016).

Actors seem to have different visions of periurbanisation, the infrastructure of this analysis. While commercial actors perceive periurbanisation as an opportunity, farmers perceive the obstacles involved in adapting cropping systems. For commercial actors, such as groceries, supermarkets and most processors, the farmers closer to the urban area are an opportunity as they are closer to their business activities and thus easily accessible. Including local farmers is also important for marketing strategies toward consumers. Nevertheless, commercial actors complain about the lack of regular supply because the same farmers are contacted for different LFS. In addition, as other studies in the area have shown, farmers do not always adapt to LFS: only 26 of the 58 farmers in the sample participated in LFS, and most of them maintained hybrid networks between conventional and alternative food chains (Filippini et al., 2016a). This study shows that farmers recognise the potential for commercialisation in LFS that periurbanisation provides, but they also recognise the impact of urban pressure on their farming practices.

Farmers' and commercial actors' differing perceptions and knowledge about the farming system must improve to develop innovation of the local agro-food system further. The farmers' adaptation to the new commercial opportunities of the nearby urban areas indicates that the process still needs to be improved for all actors in the LFS. Results of his study are consistent with those of other studies performed in the area. For example, Filippini et al. (2020) compared the viewpoints of livestock producers and supermarket managers when evaluating a food project based on the assumption that including all actors in the food chain is the only way to promote the sustainability of LFS. Sonnino (2014) suggested including all actors in the food chain to reinforce urban food security. Bloom and Hinrichs (2011) highlighted the difficulties of local buyers when interacting with local farmers. The present study provides a systematic review of the advantages and disadvantages that farmers and commercial actors encounter when they participate in LFS. The main outcome of the study is a consistent story of actors' viewpoints about the systemic functions and structures of LFS (e.g.. Lamprinopoulou et al., 2014). In this sense, it is interesting to observe how failures accumulate: grocers' lack of knowledge about the potential of PFS and lack of coordination at public and private levels causes network failures, which cause market failures. Moreover, the LFS appears to be a closed network for a few farmers who were not related to each other. This lack of connections makes it even more difficult for commercial actors to make profitable contact with farmers in LFS.

Although the results of this study are valid only for its case study, similar analysis in other areas could deepen and enrich the set of systemic failures and merits that influence system structures and functions. Among the actors usually connected to SI in the literature, the contribution of research to innovation was not considered (Lamprinopoulou et al., 2014), as the main purpose of the present study was to identify the phenomena accurately; likewise, policy-makers' contributions were not considered (Wieczorek and Hekkert, 2012). According to the literature, SI can help identify systemic measures that influence the functioning of the system innovation, especially to support policy design. Although identifying systemic measures lay beyond the objective of this study, it is possible to identify elements from this study which may improve innovation efforts due to the identification of systemic failures. In particular, it is recommended to pursue SI by coordinating individual initiatives; public institutions in particular should play a key role in developing a shared vision of PFS and LFS. There is potential for actions that coordinate all efforts in order to promote the innovation of PFS and LFS to new forms of sustainability. Doing so requires establishing a coordinated system of rules at the territorial level, along with coordinat-

ed activities that promote local food and LFS activities, to support the evolution to more sustainable LFS and PFS in the wider regional development (Sonnino, 2014). The potential of this coordination requires that research build on this analysis and integrate local and regional analysis, and the SI approach will help to integrate these levels (Klerkx et al., 2012). Future analysis should design better research projects that include policy-makers when applying a systemic policy framework (Wieczorek and Hekkert, 2012) to assess the SI of a particular area better. Finally, the use of educational tools is also recommended to provide a platform for learning and experimenting among actors (Lardon et al., 2016).

Regarding the multi-level approach, it may be complicated for researchers to leave the farm gate to address other actors and territorial processes. Comparing the data of actors, even those at the same level, may be problematic, as the data come from different sources. For example, data about food production and consumption or about farm and processor management may use different units of measure or have been obtained at different times. Research may also require scaling up from micro- to macro-analysis to create regional knowledge to influence regional development. This process may become complicated when qualitative and micro-level quantitative data obtained from actor interviews are combined with regional data. This may also occur when institutions with different objectives operate at different scales, are not used to working together, and thus generate data which are not always comparable. Nevertheless, leaving the farm gate is necessary to understand farms and the dynamics of their context better in order to improve innovation and sustainability. An interdisciplinary approach supports this perspective beyond sector-specific perspectives, which improves territorial and integrated analysis. Integrating economic, agronomic, and geographic perspectives requires dealing with different languages, concept definitions, priorities, and methods. It is not always easy to find a common basis for research, which makes the research complex and longer-term. Innovation is an evolutionary process, and fostering the sustainability of the agro-food system requires coordination between research and private and public actors. The benefits are related to using multiple skills toward a transversal purpose, recognising a variety of issues, and thus developing possible solutions.

6. CONCLUSION

In this study, SI identified systemic failures and merits, and outlined future development possibilities. Consequently, this study contributes to LFS and PFS literature by responding to claims from the literature. LFS is an innovation which may ensure adaptability and sustainable development for agriculture in periurban areas. In turn, adapting PFS involves differentiating the periurban farmers profit in LFS as an alternative model to global supply chains. LFS also represents a factor of sustainability for commercial actors who can respond to the increasing consumer demand for local and traceable high-quality food. Nevertheless, the connection between PFS and LFS needs to be reinforced further, and the SI perspective has helped to identify elements that hinder the long-term sustainability of the agro-food system. They include commercial actors' lack of knowledge about farming systems, individual initiatives of farmers that hinder more coordinated LFS, difficulties in adapting farming practices to urban pressure, a lack of dialogue with local public institutions, and a lack of coordination at the territorial level. By applying the SI perspective, this study is the first to describe the dialogue between farmers and commercial actors, which is the first step in outlining innovative systemic solutions.

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An investigation into Italian consumers' awareness, perception, knowledge of European Union quality certifications, and consumption of agri-food products carrying those certifications

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Abstract. The present study investigated Italian consumers' awareness, perception, knowledge of European Union (EU) quality certifications: Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), Traditional Specialty Guaranteed (TSG), and organic as well as the consumption of agri-food products carrying those certifications. A total of 212 consumers responsible for food purchases took part in a web-based survey between June and December 2019, inclusive. Descriptive statistics were calculated in relation to the data collected, followed by a factor analysis to reduce data dimensionality, and a cluster analysis on the latent variables generated, to identify similarities and differences among respondents. Awareness, perception, knowledge and consumption of agri-food products carrying EU quality labels has increased among consumers in recent years. The results related to the consumer's knowledge of quality-certified products showed that more than half of respondents were able to spontaneously quote examples of PDO (76%), PGI (56%) and organic food products (73%) while only 33% of participants could name at least one TSG product. The general awareness of the guarantees offered by PDO and PGI certifications was also assessed in relation to production processes, the natural and human factors of a particular environment and the reputation and quality of a particular region. Cluster analysis showed that consumers with the highest education were most likely to value EU quality certifications and support their local economies. The information obtained have practical implications for marketing and communication of European certified food products at national and international level.

Keywords: factor analysis, cluster analysis, food labels, knowledge evolution, European quality certifications.

1. INTRODUCTION

European quality certification was first introduced with Regulation (EEC) No 2081/92, which was subsequently repealed by Regulation (EC) No 510/2006, followed by Regulation (EU) No 1151/2012. Such regulations define three key labels of product quality, namely: Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and Traditional Speciality Guaranteed (TSG).

PDO are products originating in a specific place, region or in a country, whose quality or characteristics are essentially or exclusively due to a particular geographical environment with its inherent natural and human factors and whose all production steps take place in the defined geographical area.

PGI products are originating in a specific place, region or country, whose given quality, reputation or other characteristic is essentially attributable to its geographical origin and whose have at least one of the production steps taken place in the defined geographical area.

Finally, TSG are products or foodstuff that results from a mode of production, processing or composition corresponding to traditional practice for that product or foodstuff or is produced from raw materials or ingredients that are those traditionally used.

The main differences among them are related to the number of production steps that are involved in the defined geographical area, the raw materials used and the way the product is made. The quality policy aims to protect the names of specific products to promote their unique characteristics which are associated with their geographical origin, as well as their traditional know-how. The EU quality recognition enables consumers to trust and identify quality products while also helping producers to trade on the added value markets and avoid free riding. Moreover, these formal certifications help food products to be more competitive in the global market (Carbone, 2018).

The European Parliament and Council have also established quality certifications for organic agri-food products (Regulation (EU) No 2018/848). According to this regulation the organic products were developed to respond to a specific market in which consumers were demanding for products whose production's promotes environmental protection and animal welfare, maintains the biodiversity of Europe, contributes to rural development.The distribution of quality-certified products across Europe is not homogeneous, as more than 70% of the total products originate from only five countries, including Italy (21%) , France (17%), Spain (14%), Portugal (10%) and Greece (8%) (EU Commission, 2019). As for consumers perception of these products and their characteristics the distribution is varying (Profeta *et al*., 2010). Indeed, Aprile and Gallina (2008) reported a level of awareness of 30% with regard to PDO, PGI and STG labels among Italian consumers, whereas Verbeke *et al.* (2012) observed that 23% of the Italian respondents were aware of the PDO certification, 38% were familiar with the PGI certification and 22% recognized the TSG certification. In Northern European countries, consumers' awareness of quality recognition is generally low (Jordana, 2000; Profeta *et al.,* 2010; Vanhonacker *et al*., 2010) but is increasing, as these products seem to capture new segments on the market (European Commission, 2018).

In countries specialized in the production of quality-certified food, PDO/PGI labels are reported to be important and play a role in the consumers' decision-making process as well as on their willingness to pay, as these products have a favourable image (Scarpa and Del Giudice, 2004; van Ittersum et al., 2007, Vecchio and Annunziata, 2011), however, other studies (Platania and Privitiera, 2006; Grunert and Aachmann, 2016) have reported evidence to the contrary. Although the PDO/PGI labels appeared to be important, Aprile *et al*. (2016) observed that only a small proportion of consumers was able to correctly associate PDO/PGI/organic farming characteristics to their respective labels. However, the organic farming label seemed to be more widely recognized among EU consumers, irrespective of their own national level of food quality specialization (European Commission, 2018).

The simultaneous investigation of perception, awareness, understanding, knowledge, decision-making and consumption of the European quality certifications was often hampered by the limited sample size, as well as the difficulty in retrieving information from the consumers' questionnaire. Indeed, many of the studies concentrated primarily on one aspect, with the majority focusing on the decision-making process, measured generally using the conjoint analysis (Krystallis and Ness, 2005; Mesias *et al.,* 2005; Capelli *et al*., 2014). To the authors' knowledge, no research conducted among Italian consumers has ever attempted to determine all those aspects in one single study. Another important issue was the often limited geographical distribution of the sample of respondents collected, which was primarily restricted to the main cities or to certain provinces (Van der Lans et al., 2001; Arfini and Pazzona, 2014; Ceschi *et al*., 2018).

We focused our research on the last EU Regulation' (No 1151/2012) main objective (''to help producers of agricultural products and foodstuffs to communicate the

product characteristics and farming attributes of those products and foodstuffs to buyers and consumers'') and tried to study if this goal was reached, if this regulation can be considered a proper tool in communicating those food's attributes to consumers, or if EU should find a better suited solution. For our study' objective we considered consumers perception, awareness, knowledge, and consumption of the PDO/PGI/TSG being the best way to measure the regulation objective's accomplishment.

Given this, an overview of the past and current situation was required to understand whether there was any positive change in the consumers attitudes towards these certifications.

Confirmation of the existence of a real evolution will help prove the effectiveness and efficiency of PDO/PGI/TSG certifications as a marketing tool, therefore the EU Regulation (No 1151/2021) could be considered successful, reaching one of its main objectives.

New policies and communication efforts could be used to enhance consumers' curiosity in relation to products that are PDO/PG/TSG/organic certified.

2. MATERIAL AND METHODS

2.1 The survey

Between June and December 2019, a convenience sample made of 312 consumers across Italy replied to the web-based survey, formulated to conduct the current research. Of these, only 212 declared that they were responsible for the food purchases in the household, therefore, only these 212 consumers were invited to complete the whole questionnaire. The survey aimed to examine European quality certifications, to understand whether they were recognized by the consumers (awareness), whether the consumers perceive the guarantees offered by the PDO/PGI/TSG, Organic certifications (perception), approved their use (knowledge) and whether they played a role in consumers' buying decision process, thereby establishing whether these certifications truly had an impact on the purchasing decision (consumption). Another purpose of the questionnaire was to verify whether the market is stratified into different consumer categories with different attitudes towards the certifications, the final goal being to suggest different solutions for their promotion and valorisation. The questionnaire[1] was created in conjunction with the literature on consumer behaviour relating to typical foods and food labelling. Initially, a pilot test (n=20) was performed to ensure that the formulated questions were clear and understandable for consumers. Should a question be regarded as unclear, this was revised and modified accordingly for the final questionnaire.

The final questionnaire was sub-divided into six sections, addressing specific issues as following:

i) the first section (one question) contained the filter question, as the survey was designed for those responsible for the food purchases for the family. The answer to this question was a dummy variable, indicating whether the respondent was (i.e.,1) or not (i.e., 0) responsible for the household food purchasing.

If the participant was not responsible for food purchases in the household, he/she would be redirected to the last section, where he/she would complete only the socio-demographic questions.

ii) the second section (4 questions) examined consumers' perception of food quality and safety, the importance of the EU quality certifications and other different food characteristics when choosing a food product, the significance of the food label and consumers' feelings towards food law compliance and different production types and techniques. Five-point Likert scale question were used in this section, with 1 corresponding to ''Not at all'' and 5 to ''Very Important''.

iii) the third section (8 questions) covered consumers' awareness and knowledge of the EU quality certificates (PDO/PGI/TSG) and the organic certificate, attempting to identify the main differences between the PDO/PGI/TSG and organic products, and conventional products. In this section multiple image choice questions was used when respondents had to choose which of the shown logos they knew, and multiple choice questions when they had to select the right definitions of the EU quality certifications. Also, the previously used five-point Likert scale question was used (1= ''Not at all'' and 5= ''Very Important'').

iv) the fourth section (12 questions) analysed consumers', knowledge and consumption of EU quality-certified products as well as organic products. Each of these quality labels was again analysed separately. Here three-point Likert scale questions were used (No=0, Yes=1, Maybe=2). In order to test their knowledge, the participants were asked to give some examples of each of these types of products. In addition, in order to establish their consumption of products baring these certification they were asked for examples of the last PDO/PGI/TSG and organic products they had bought during the last three months. For this purpose, open-ended questions were used in all the above cases.

v) the fifth section (16 questions) consisted of an analysis of 16 Provolone Dolce cards, with different combinations of various characteristics, thereby collect-

[1] The questionnaire is available upon request.

ing the data needed for a conjoint analysis; however, this will not be considered further in the present study but will form part of an alternative ongoing project.

vi) the sixth section (10 questions) used demographic questions to cover the socio-demographic aspects of the respondents; the formulated questions evaluated the participants' city and area of residence, sex, age, number of family members, education level, job, civil status, and annual income.

The questionnaire was distributed online, and was shared on Facebook pages and groups, LinkedIn, WhatsApp, Messenger, as well as on certain cooking blogs. Therefore, the actual number of people viewing the survey is unknown, however, the total number of respondents is reported above.

2.2 Statistical analysis

Descriptive statistics were calculated in relation to the data collected between the second and the sixth sections of results, using a basic script in Python (Python Software Foundation, ver. 3.6). The software IBM SPSS Statistics (ver. 24.0, IBM Corp., Armonk, NY) was employed to conduct multivariate statistical analysis within a multiple-step framework. In the first step, we carried out a factorial analysis in order to reduce the dimensionality of the data collected into a smaller set of key factors, that would be easier to explain. The variables covered in the analysis focused on different food characteristics at the point of purchase, the importance of different safety and quality food characteristics, attitudes towards EU quality-certified products, the perception of law compliance, production types and techniques, as well as the attention given to various information on the label. A 5-point Likert scale was used to measure all the variables included in the factor analysis. The optimal number of latent variables selected for the subsequent analyses was chosen, based on the lowest number of components with associated eigenvalues greater than 1 (Kaiser, 1960) and based on the proportion of the total variance explained by the retained factors of at least 50%. In the second step, a cluster analysis was applied to the latent variables previously generated and selected with the aim of organizing the respondents into homogenous groups. Prior to the cluster analysis, data were processed with the agglomerative hierarchical procedure. According to Ward's criterion of aggregation, 10 iterations with mobile centres were completed. Based on a visual inspection of the generated dendrogram, the optimal number of clusters to specify in the K-means method was set at 4. This type of analysis applied Euclidean distance to define similarities and differences within the clusters.

3. RESULTS AND DISCUSSION

3.1 Description of the sample

The results reporting the socio-demographic aspects of the sample used in the present study, are depicted in Table 1.

The sample analysed in the present study may not be completely representative of the Italian population as the criteria that was used for the sampling is convenience. There is an over-representation of women and younger respondents, with 48% of the sample aged between 18 and 35 years old, that may be because the questionnaire was distributed online, and the population tends to not have access to the Internet or computer skills. 64% of the respondents were women and this over-representation can be explained by the fact that our respondents needed to be responsible for the food purchases in their household, and women, generally, have that responsibility.

More than 70% of the respondents had at least a bachelor's degree, with 11% having a PhD. Having this highly-educated sample can be explained by the method used to administer the questionnaire. Moreover, the North-Eastern region of the country is also overrepresented (52%). This can be explained as the questionnaire was disseminated with the social network of the authors , so it may have inflated the number of respondents from a limited geographical area.

The most popular occupations were office worker (37%), freelancer (14%), student (14%) and housewife (8%). The 17% declared an annual income less than 10,000 € while 12% declared an income greater than 40,000 €. The non-representativeness of our sample might have some influence on the final results. For example, the women over-representation could have generated greater results, as found by Dekhili et al. (2011), or contrary could have shown lower ones as sometimes men presented better knowledge of these certifications (Verbeke et al., 2012). These both same studies shown that older groups of people have a higher awareness and use of the EU quality certifications. As in our sample the older groups were underrepresented (45-70 years old) we believe this could result in lower outcomes. Having a higher educated sample might have introduced some bias as it is expected that the higher the education level, the higher the knowledge resulting in a more positive attitude towards these certifications.

3.2 Awareness and knowledge of European quality certifications

In the third section of the questionnaire (awareness and knowledge) the consumers were shown four

Table 1. Socio-demographic distribution of the collected sample by comparison with the Italian population.

Variable	Levels	Frequency (%)	Population (%)
Age (in years)	18-25	9	10
	26-35	39	16
	36-45	22	20
	46-55	17	24
	56-70	13	30
Gender	Female	64	51
	Male	36	49
	No education/Elementary school	0	17
Education	Junior high school qualification	3	32
	High school qualification	27	36
	Bachelor's degree/ Master's degree/Post graduate training/PhD	70	15
Civil status	Single	57	42
	Married	39	47
	Divorced	2	3
	In a relationship	1	
	Separated	1	
Family members	1	17	33
	2	28	27
	3-4	42	35
	>4	13	5
Geographical Distribution	North East	51	19
	North West	19	27
	South	12	23
	Centre	11	20
	Islands	7	11
Occupation	Office worker	37	
	Freelance	14	
	Student/PhD student	14	
	Housewife	8	
	Teacher	4	
	Research/Academia jobs	4	
	Unemployed	5	
	Worker	3.5	
	Retired	1.0	
	Jobseeker	1.5	
	Entrepreneur	3.0	
	Food related jobs (chefs/food bloggers)	1.0	
	Other	4	
Average annual income (€)	< 10,000	17	
	10,000 – 20,000	38	
	20,000 – 40,000	33	
	40,000 – 50,000	5	
	> 50,000	7	
Area of origin	Rural	30%	
	Urban	70%	

* Istat (National Statistics Institute) data extracted in November 2019.

EU quality logos, PDO, PGI, TSG and organic farming logos and were asked to select those that they were aware of. The results indicated that the logo people were more aware of was the PGI, selected by 82% of respondents, followed by the PDO (76%) and the organic logo (68%), while people were least aware of the TSG with only 34% of them. 25% of the respondents declared that they were aware of all four logos, 30% were aware of three logos, 25% of two logos and 20%, just of one logo (Appendix, Figure 1). These findings were higher than those reported in a study by Aprile and Galina (2008) in which the PDO, PGI, TSG and organic mark were recognized by 30%, 16%, 3.5% and 41% of the interviewees, respectively. Arfini (1999) demonstrated that 41.8% of Italian consumers were aware of the presence of a PDO-labelled food product in the food market. Similar results were found in a later study by Platania and Privitiera (2006) that assessed the consumer appraisal of the Italian PDO Soppressata salami, which reported that 42% of Italian consumers were aware of the PDO label. As explained in the review conducted by Grunert and Aachmann (2016), and identified in the present study, the higher degree of consumer awareness of European quality labels depended on the time period in which the study was undertaken.

To further investigate the self-declared awareness and consumption of the EU quality certifications, participants were then asked how well they knew the certified products and how often they bought them. The PDO certified products were bought most frequently, with 68% declaring that they regularly (18%) and sometimes (50%) purchased them. Conversely, TSG products were bought least often (4% regularly and 16% sometimes; Appendix, Table 1).

Respondents were then presented with six official definitions extracted from Regulation (EU) No. 1151/2012 and had to choose for each of them the corresponding EU certification (PDO, PGI, TSG or none).

For both statements that defined the PDO's out of all respondents 42% were able to identify correctly the one that refers to ''the production steps of which all take place in the defined geographical area" and 43% "whose quality or characteristics are essentially or exclusively due to a particular geographical environment with its inherent natural and human factors". (Appendix, Figure 2)

For the PGI defining statements, the one describing the production steps, was correctly identified by 55%, but only 38% did so for the statement explaining that the quality and reputation are given by the geographical origin.

As for the TSG statements, in both cases almost half of the respondents identified the right statements: 46% explaining ''the traditional production, processing, and composition for that products'' and 49% for the statement related to the raw materials and ingredients traditionally used, for at least 30 years.

Data from Table 2 show the mean and the standard deviations of the elements that consumers used to distinguish the certified products from the conventional products.

The "place of the origin" mean was the highest in the case of PDO (4.64), PGI (4.49), TSG (3.73), followed by the "EU quality logo" (PDO 4.29, PGI 4.21, TSG 3.61) which was seen as the most important characteristic for the organically-certified products (4.18), followed by "price" (4.01). The less relevant features were "brand" and "point of purchase" for all four certifications. In accordance with these data, other studies (Contini *et*

Table 2. Means and Standard Deviation of the different attributes distinguishing between EU quality-certified products and conventional products.

EU certification	Attribute	Mean	Standard Deviation
PDO	Price	4.01	0.76
	Brand (National Brand/Private Labels)	3.62	0.91
	EU quality logo	4.29	0.78
	Appearance	4.00	0.89
	Place of origin	4.64	0.53
	Point of purchase	3.44	0.98
PGI	Price	3.91	0.90
	Brand (National Brand/Private Labels)	3.52	1.00
	EU quality logo	4.21	0.93
	Appearance	3.94	1.00
	Place of origin	4.49	0.77
	Point of purchase	3.46	1.12
TSG	Price	3.43	1.56
	Brand (National Brand/Private Labels)	3.07	1.46
	EU quality logo	3.61	1.62
	Appearance	3.37	1.58
	Place of origin	3.73	1.69
	Point of purchase	3.08	1.60
Organic	Price	4.01	1.05
	Brand (National Brand/Private Labels)	3.48	1.10
	EU quality logo	4.18	1.03
	Appearance	3.86	1.12
	Place of origin	3.91	1.24
	Point of purchase	3.36	1.24

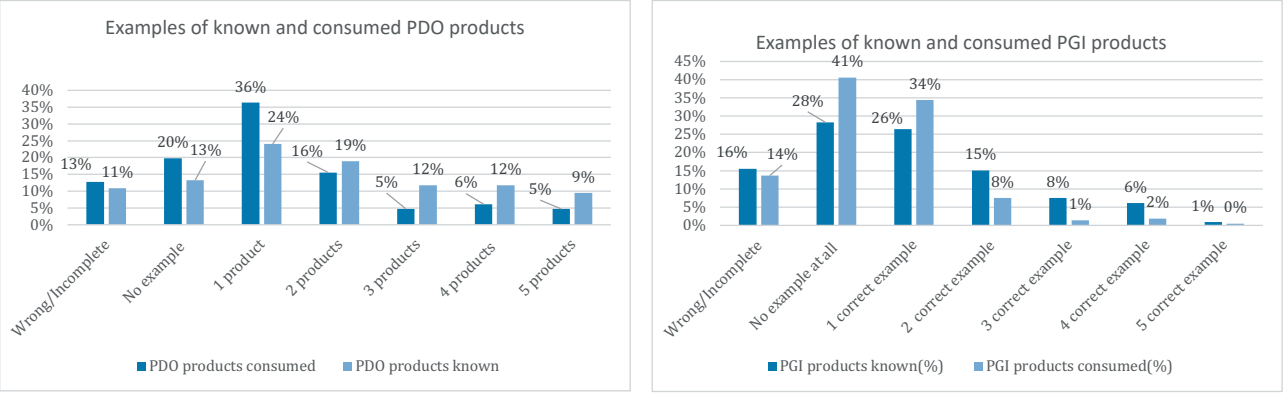

Figure 1. Examples of known and bought PDO and PGI products.

al., 2016; Vanhonacker *et al.*, 2010b) revealed that "place of origin" was the most important attribute in distinguishing and choosing between European quality-certified products and conventional products. The choice of "price" as a distinguishing element for quality-certified products can be viewed as a signal of a high-quality product, as confirmed by previous studies conducted by Grunert *et al.* (2000) and Verberke *et al.* (2007) Santeramo (2020) suggested that adding regional certification labels (e.g., Protected Designation of Origin–PDO, Protected Geographical Indication–PGI, American Viticultural Area–AVA) or regional information increases consumers' confidence on the product quality.

3.3 Knowledge and consumption of the European quality certifications

Results reporting the opinions of respondents in relation to the food safety of European quality-certified products are detailed in Table 3. Food safety was used in this section as a way to study consumer's knowledge of EU quality certifications as those products are believed to have a higher level of food safety.

Table 3. Consumers' perception of the safety of EU quality-certified products.

	In your opinion, are EU quality-certified products safer than other products?		
	Yes	No	I do not know
PDO products	58%	22%	20%
PGI products	50%	26%	24%
TSG products	25%	25%	50%
Organic products	39%	40%	21%

When respondents were asked whether they considered the PDO certified products safer than conventional products, 58% of the respondents replied "yes" and 22% "no", while 20% responded "I don't know". Similar results were recorded with regard to the PGI certified products, with 50% choosing "yes", 26% "no" and 24% "I don't know". Organic farming products registered the highest percentage for "no" with 40%, with only 39% replying "yes". In relation to TSG products, 50% of the respondents declared they "didn't know" if they were safer or not, while 25% replied "yes" and 25% answered "no".

Figure 1 reveals evidence of the consumers' actual knowledge of quality-certified products, as they were asked if they could name any PDO, PGI, TSG or organic products, without being prompted.

The results show that in relation to PDO products, over 11% of the sample provided an incorrect answer, around 13% were unable to recall any PDO products, 24% gave one example, 19% two examples, 12% three or four examples, and 9% five examples. As for the PGI products, over 16% of the individuals provided an incorrect answer, around 28% were not able to quote any example, 26% gave one example, 15% two examples, 8% three examples, 6% four examples and 1% five examples.

With regards to TSG products, 13% of respondents gave an incorrect answer, 55% were unable to cite any TSG product, 25% remembered one example, while 7% provided two which is the maximum of right examples possible in Italy. 27% of participants were unable to recall any organic products and 73% provided one or more organic food examples.

In relation to the organic product results, de Magistris and Gracia (2012) showed that more than 50% of consumers declare to be a habitual buyer of organic food products and around 59% of Italian consumers state that

"probably yes" or "definitely yes", they pay attention to organic label when shopping organic food products.

These results are in accordance with the self-assessed knowledge relating to logos (discussed above in the "awareness and knowledge of European quality certifications" section) except in the evaluation of the PGI products, in which the degree of self-assessed knowledge was higher than the actual knowledge with a frequency of 26%. The results in these findings are higher than those in previous studies like Vecchio and Annunziata (2011) who considered PDO/PGI products together and revealed that over 37% of the respondents gave an incorrect answer, around 29% were unable to recall any PDO or PGI food, 20% gave less than two names and 14% less than four. Examining the category to which the examples provided belong, it was observed that in the case of the PDO products, the correctly cited products belonged to the cheese category, the meat products category (cooked, salted, smoked), the fresh or processed category (fruit, vegetables, cereals) and finally the oils and fat category, with figures of 60%, 18%, 3% and 1%, respectively.

In the case of the PGI products, 34% of the correct examples were associated with the meat products category (cooked, salted, smoked), the fresh or processed category (fruit, vegetables, cereals) recorded 26%, closely followed by vinegar at 24% (category known as "other products"). The results correspond to the consumption value of Italian PDOs and PGIs in which cheese and prepared meats account for 84% of its total sales (ISMEA, 2018).

Regarding these findings Santeramo and Lamonaca (2020), found that Geographical Labels are effective differentiation tool although their relevance varies across products and origins. For instance, GL is the main differentiation tool for wine, but it is of low relevance for low-prices products and in different national markets. Costanigro et al. (2010) sustains the same results as to the less expensive products, showing that the consumer may not see the value (in terms of search costs) in critically differentiating across many individual producers when buying less expensive products (such as grains, fruits and vegetables) but affirms the contrary when it comes to purchasing more expensive products (such as wine and olive oil), as the incentive to learn about differences in quality across brand names is more pronounced, allowing brand names to capture a larger share of the reputation premium.

To determine the consumers' actual use of EU quality certifications and their accurate consumption, respondents were asked to recall from the previously given examples which products they had purchased during the last three months (Figure 3). In relation to the PDO certification, 13% of the individuals returned an incorrect answer, 20% were not able to provide any example, 36% indicated one example, 16% two examples, 5% three examples, 6% four examples and 5% five examples. In the case of the PGI certification, incorrect or incomplete examples were provided by 14% of the respondents and 41% gave no example at all. Of the correct examples, 34% provided one, 8% gave two, 1% three, 2% four and none (0%) of the participants provided five correct examples. As for the organically certified products, 44% of the respondents provided no example at all, while 56% gave one or more examples.

Aprile and Gallina (2008) showed the interviewees a list of nine products, from each category considered; all products were PDO or PGI certified and respondents were asked to choose those that they purchased more frequently. The more frequent categories were the cheese category, meat products category (cooked, salted, smoked), fruit and vegetables Their findings were very similar to ours.

It has been observed that some of the products that appeared in the study of Aprile and Gallina (2008) are not mentioned by our respondents, however, certain new names were mentioned. Another difference is the higher percentage found in the comparable study, but this is due to the fact that their respondents selected names from a given list, while our respondents gave the examples spontaneously, without any help or suggestion.

Our descriptive analysis showed that consumers were asked to provide examples of EU quality-certified products; in most cases, the responses provided contained at least one well-known food on the national market (e.g., Parmigiano Reggiano, Mozzarella di Bufala Campana, Gorgonzola, Grana Padano) but their answers were not limited to these. Related to these findings, Deselnicu et al. (2013) revealed that the institutional framework for the Geographical Indications was found to matter: within the same country, quality assurance certifications with higher quality standards (such as PDO) receive higher premiums than less stringent ones (such as PGI). Moreover, when multiple labelling certifications with different minimum quality standard coexist (as for PDOs and PGIs in Europe), the price premium associated with the labels is lower than when a single label is used (as for the GI trademark in the United States). Leufkens (2018) tried to prove the positive value of a GI quality signal (i.e. label) by quantifying its monetary value for the consumers and found that consumers are willing to pay a marginal premium for the GI, by an average of 11.5 percent, while the PDO alone achieves an LE of 13.6 and a PGI of 6.2 percent.

3.4 Perception, attitudes towards quality food products and purchasing habits

In relation to the questions in the second section (Appendix, Table 2), different characteristics were listed, and respondents had to evaluate them using a 5-point Likert scale. With regard to the various aspects that consumers recognized as "very important" and "relatively important" in their food purchasing process, the most important was hygiene standards (97%), followed by price (92%), appearance (88%), nutritional value (77%) and PDO certification (75%). The aspects that were seen as less important, registering the highest percentage of the options "indifferent", "not much" and "not at all" were TSG certifications (65%), organic certifications (51%), brand (38%) and PGI certifications (33%).

When asked about the characteristics of a safe and quality product, the absence of undesirable chemicals and microorganisms was evaluated as "very" and "relatively important" (98%), followed by compliance with national and European laws relating to food and the environmental area (96%), controlled and certified production sites (89%), products that satisfy the senses, are well prepared and preserved (89%), country of origin (86%), sustainable production techniques (80%) and PDO certification (74%). The lowest scores on the Likert scale ("indifferent", "not much" and "not at all") were again recorded in relation to TSG certification (59%), popular brand (58%) and organic certification (47%).

With reference to the various information found on the product label, the components considered to be "very" and "relatively important" were expiry and use-by date (94%), ingredients (92%) and information relating to the producer and place of production (89%), while 23% regarded nutritional characteristics as being "indifferent", "not much" and "not at all important".

The last question in this section revealed that 88% of the respondents claimed to purchase Italian food whenever they could, 74% claimed to be very proud of the PDO, PGI and TSG products produced in their area, municipality or country. However, only 67% felt that they were supporting local farmers when they bought PDO, PGI and TSG products. As for the affirmation that PDO, PGI and TSG trademark products are too expensive, 40% either agreed or completely agreed, 39% disagreed or completely disagreed, while 21% were neutral. Similar to our findings Deselnicu et al. (2013) shown that stricter regulations may signal increased benefits to consumers in the form of food safety, quality assurance, and stronger cultural or heritage connection, prompting a higher willingness to pay for products that are more closely regulated. Also, more stringent regulations for the PDO designation appear to secure a higher price premium than its less stringent quality-assurance counterpart (PGI).

3.5 Exploratory factor analysis (EFA)

A series of exploratory factor analyses (EFA) were conducted using the questions and affirmations from the survey's second section. Before we carried out the EFA, the values of the bivariate correlation matrix of all items were analysed, and where the bivariate correlation scores were greater than 0.8, one of the pair's items was removed, as suggested by Field (2013). Additionally, the multicollinearity was tested via the determinant of the matrix, whose value of 0.1 exceeded the minimal value of 0.00001. Furthermore, our factor model Kaiser-Meyer -Olkin's measure of 0.820 proved the adequacy of the sample size. Bartlett's test of Sphericity was significant ($P< 0.001$). The Varimax rotation method was employed and the eigenvalues greater than 1 were established as borderlines for the factors extracted.

The analyses eventually resulted in the selection of a six-component solution, based on 24 of the 27 initial variables. The six extracted components accounted for 56.32% of the total variance in the data, respecting the rule of at least 50% (Streiner, 1994).

Items in this six-component solution were regarded as high and moderately high, loading higher than 0.400 on each component (Kleine, 2014). Their Cronbach's alpha reliability tests showed increased reliability, with values higher than 0.60 (up to 0.79).

Table 4 contains the components resulted from the factorial analysis. The first component "Product composition and characteristics " comprised variables such as nutritional and organoleptic characteristics, ingredients and label information.

The second component "Product'origin " describe, as the name suggests, the importance given to the origin of the product and of the raw materials producer's information, as well consumers' pride in buying EU quality-certified food that is locally produced. The third component "EU quality certifications" describes the importance consumers attach to the European quality certifications (PDO/PGI/TSG) and how buying EU certified food supports local farmers. The fourth component "Product visual presentation relates to the value attributed by consumers to the products appearance and appeal and the expiry date. The fifth component "product law and hygienic compliance" examined the significance of hygiene standards, law compliance, absence of unwanted chemicals and controlled and certified production sites in consumers' food choices.

The sixth component "Product price and brand" considered the impact that price and popular brand had

Table 4. Factor analysis on the components associated with respondents' purchasing intent.

Items	Components					
	Product' composition and characteristics	Product' origin	EU quality certifications	Product' visual presentation	Product law and hygienic compliance	Product price and brand
Nutritional characteristics	0.746					
Ingredients	0.639					
SustProd techniques	0.595					
Label information	0.556					
Producers' experience	0.540					
Biological mark (Organic)	0.526					
Organoleptic characteristics	0.525					
Country of origin		0.786				
Frequency of buying		0.728				
Local raw materials		0.629				
Pride EU marks		0.546				
Producer information		0.519				
PDO trademark			0.713			
TSG trademark			0.604			
Support for local production			0.476			
Appeal, conservation				0.788		
Food aspect				0.779		
Expiry date				0.612		
Absence of UW chemicals					0.733	
Law compliance					0.725	
Hygiene standards					0.577	
CC Production sites					0.431	
Cost, expensiveness of EU trademarks						0.790
Popularity, brand						0.592
Explained variance, %	24.942	9.315	6.807	5.972	4.985	4.295
Cumulative variance, %	24.942	34.257	41.064	47.036	52.020	56.315

*The items are ordered by dimension, and the small coefficients with an absolute value below 0.300 have been eliminated.

on consumer choices. The six components that were obtained using the factor analysis were then used as variables in a cluster analysis that divided our sample into four groups, with maximized homogeneity within the individual groups and minimized between them.

Table 5 presents a detailed representation of the socio-demographic characteristics of the four clusters.

3.6 The socio-demographic characteristics of the four clusters

From a socio-demographic perspective, the first cluster is defined as the most gender-balanced (47% men and 53% women), predominantly from urban areas (73%) with the highest concentration of young consumers, as 83% were aged between 18 and 45 years. This group had the highest proportion of one member families (27%), with 53% earning at least 20,000 €/year (12% of these > 40,000 €/year). The respondents' occupations were from research and academia (4%), entrepreneurs (5%), students/PhD (16%) and retired people (4% the only cluster in which this group was represented).

The second cluster had the highest percentage of primary school graduates together with the highest percentage of unemployed people (10%) and office workers (65%) but also the lowest number of freelancers (5%). In this cluster none of the participants earned more than 40,000 €/year, half of the participants were made up of families with three to four members and a quarter had four members or more.

The third cluster is characterized by an urban population, consisting predominantly of women (74%), characterizes this group, with more than 40% being over 45

Table 5. Socio-demographic distribution among clusters.

Variables	Level	Cluster 1 "visual presentation enthusiasts"	Cluster 2 "origin enthusiasts"	Cluster 3 "food provenance and image enthusiasts"	Cluster 4 "food regulations enthusiasts"
Area of origin	Rural	27%	40%	27%	33%
	Urban	73%	60%	73%	67%
Gender	Male	47%	60%	26%	39%
	Female	53%	40%	74%	61%
Age	18-25	6%	20%	11%	3%
	26-35	55%	40%	26%	58%
	36-45	22%	20%	23%	21%
	46-55	10%	15%	27%	3%
	56-70	7%	5%	13%	15%
Number of family members	1	27%	10%	11%	24%
	2	35%	15%	24%	43%
	3-4	35%	50%	50%	24%
	>4	3%	25%	15%	9%
Education	No title	0%	0%	0%	0%
	Elementary or middle school	2%	10%	1%	0%
	High school	18%	15%	35%	18%
	Bachelor or master's degree/PhD	80%	75%	64%	82%
Civil Status	Single	65%	65%	48%	67%
	Married/In a domestic relationship	35%	35%	47%	30%
	Divorced/ Separated	0%	0%	5%	3%
Average annual income	<10,000 €	12%	25%	15%	24%
	10,000-20,000 €	20%	40%	39%	45%
	20,000-40,000 €	41%	35%	33%	21%
	40,000-50,000 €	4%	0%	6%	3%
	>50,000 €	8%	0%	7%	6%
Occupation	Homemaker / Housewife	8%	5%	8%	6%
	Unemployed	6%	10%	1%	0%
	Office worker	37%	65%	31%	45%
	School teacher	2%	0%	4%	6%
	Freelancer	14%	5%	15%	15%
	Worker	4%	0%	5%	0%
	Retired	4%	0%	0%	0%
	Research/Academia Jobs	4%	0%	9	12
	Student/PhD student	16	10	18	6
	Entrepreneur	5%	0%	5%	0%
	Food related jobs(blogger/chef)	0%	0%	3%	3
	Job seeker	0%	0%	2%	6%
	Others	0%	5	4	1

years old; the highest number of high school only graduates were found in this group (35%) and single (48%) and married (47%) people were equally represented. It was the most diversified group in terms of occupation (teachers, food related workers, researchers, workers, freelancers, office workers).

The fourth cluster consisted of single individuals with a high standard of education (> 82% had at least a bachelor's degree) and low annual income, as 69% earned less than 20,000 €/year; this cluster comprised primarily office workers, research workers, housewives and freelancers.

3.7 The clusters attitudes towards the analysed variables

As regards to the considered variables (Table 6), first cluster ''visual presentation enthusiasts' is characterized by respondents that pay most attention to appeal, appearance, and availability. They also considered law compliance and the healthiness of the product as particularly important in their food choice. This group recorded the lowest interest in producer's information, origin of raw materials and of the product. In addition, EU quality certifications and support for local economies were insignificant to this group.

By comparison with the first cluster, the second cluster ''origin enthusiasts'' valued most the producer's information and the origin of raw materials and of the product. This cluster recognized extrinsic characteristics (price, brand) as decisive. Law compliance and the healthiness of the product were less important elements for this group. Organoleptic, nutritional and sustainability characteristics were also regarded as insignificant.

The third cluster ''food provenance and image enthusiasts'' was the only cluster that valued all the components positively (Table 6), demonstrating a great interest in producer's information, origin of raw materials and of the product, as well as appeal, appearance, and availability.

Of all the clusters, the last cluster ''food regulations enthusiasts'' attributed the highest value to law compliance and the healthiness of the product. EU quality certifications and support for local economies, as well as producer's information and the origin of raw materials and of the product, were essential elements of this group's components.

4. CONCLUSIONS AND RECCOMENDATIONS

Our results outlined that the level of perception, awareness, knowledge and consumption of EU quality labels has increased considerably among Italian consumers in recent years.

With respect to geographical indications, a widespread awareness of the guarantees offered by the PDO and PGI marks in relation to production steps, the natural and human factors of a particular environment and the reputation and quality of a region were assessed. As for the traditional specialties (TSG) an extensive knowledge regarding the traditional practices of production, process and composition, as well as ingredients and raw materials was identified. New policy and communication efforts could be used by the consortia to enhance consumers' curiosity towards products that are PDO/PG/TSG or organic certified.

Our results allow us to formulate some suggestions for the policy makers as well as for the Consortia and the producers of the PDO/PGI/TSG/Organic products. Seeing that our consumers were divided in four clusters we assume that even at the national/international level there is heterogeneity as regards to these labels, therefore for each of the cluster we propose some communication strategy.

For the "Visual presentation enthusiast" cluster, the strategy adopted should concentrate more on the way these products are presented, using attractive packaging but also one that helps reflect the look of the products.

For the "Origin enthusiasts" the message of the communication campaign should point out how these products are unique in the sense of the typicity that is given by the particular geographical areas where they are produce and by the raw materials they are made of, strengthening the importance that these two elements have on the final product.

As to the ''Food provenance and image enthusiasts'' cluster considering their positive attitude towards all the quality certified foods' attributes, we believe that the message the policy makers as well as the producers and Consortia should sponsor and publicize, is one

Table 6. Final Cluster Centres.

	Cluster			
	1 "visual presentation enthusiasts" (8%)	2 "origin enthusiasts" (53%)	3 "food provenance and image enthusiasts" (11%)	4 "food regulations enthusiasts" (28%)
Product' composition and characteristics	-0.389	-0.443	0.242	0.039
Product' origin	-1.267	0.300	0.471	0.130
EU quality certifications	-0.417	-0.086	0.171	0.101
Product visual presentation	0.309	-0.109	0.344	-1.541
Product law compliance	0.126	-2.387	0.289	0.295
Product price and brand	-0.208	0.113	0.238	-0.555

that could produce some ethical and altruistic motives, therefore the message must stress out the support these products bring to the local economy in the area in terms of jobs and income.

The "Food regulations enthusiasts" could be conquered by campaigns that point out how these quality products follow very strict production rules, with regular checks on healthiness, sanitary and organoleptic elements, and that this is one of the elements that differentiate them from the conventional products that might have more relaxed rules and less controls.

One limitation of the present study is the fact that the sample is not strictly statistically-representative of the Italian population. The sample is biased towards relatively younger and highly educated shoppers and female consumers. Therefore, additional qualitative and quantitative research needs to be done with a larger and representative sample, to extend the legitimacy of the findings and to generalize the results to represent the national population. Another possible limitation of the study, is that since the questionnaire was our investigation instrument there might have been a certain predisposition to socially desirable responding, or as Martin and Nagao (1989) better described it, a tendency to give answers that make the respondent look good, or the tendency "to stretch the truth in an effort to make a good impression".

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APPENDIX

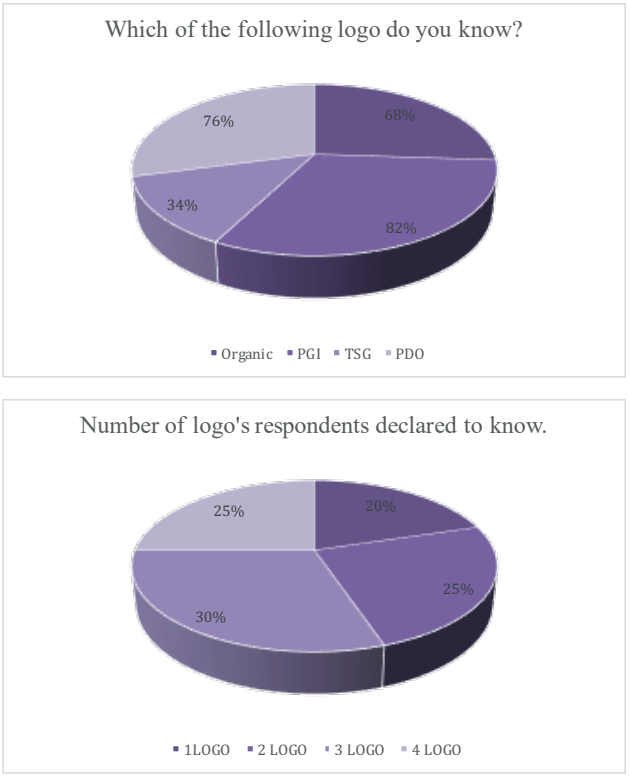

Figure 1. Self-declared knowledge of the EU quality certifications logos

Table 1. Self-declared knowledge and frequency of buying of the EU quality certifications.

Certifications	I regularly buy them	I know and I buy them sometimes	I know them	I don't know them
PDO certified	18%	50%	27%	5%
PGI certified	15%	48%	30%	8%
TSG certified	4%	16%	24%	57%
Organic certified	12%	43%	38%	7%

Table 2. Importance of different attributes when food shopping.

	Very important	Pretty important	Indifferent	Not much	Not at all important
Hygienic Standards	78%	19%	2%	0%	
Brand	6%	56%	25%	9%	4%
PDO certification	19%	56%	17%	7%	2%
Appearance	46%	42%	7%	3%	1%
PGI certification	15%	52%	22%	9%	2%
Price	39%	53%	6%	2%	0%
Nutritional Values	35%	42%	18%	2%	3%
Organic certification	12%	37%	27%	14%	10%
TSG certification	5%	30%	38%	12%	15%

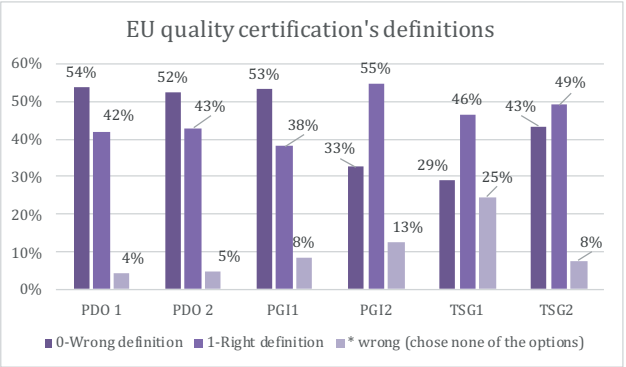

Figure 2. EU quality certifications definitions.

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Wine after the pandemic? All the doubts in a glass

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Abstract. COVID-19 has triggered an unprecedented global crisis, the increasing recessions in many countries and related trade uncertainties are affecting the whole wine sector, from production to distribution, sales, and consumption. While the full recovery is still uncertain, and even worse scenarios are possible if it takes longer to recover trust and financial stability on wine markets, the crisis risks to jeopardies recent developments and sustainability in wine territories. Building on a tailored revision with a mixed-method participatory research process of the conceptual framework on Condition, Strategies, and Performance of Grando et al. (2020), we offer a critical reflection made by researchers and stakeholders supporting several socio-economic narratives and policy implications in the light of the current crisis. Distinguishing between short and long-term implications, we analyse the impact of disruptive changes in the external and internal conditions of the business environment, the strategies adopted by the wineries and their implication on performances, as well as a reflection on the policy needs to alleviate the ongoing suffering of the sector. The speed and scope of the pandemic crisis underscore the need for the wine sector to become more resilient by increasing the ability to cooperate and coordinate among supply chain actors and between policy levels. The latter offers a reflection on the balance between short-term interventions and the complementarity of post-2020 CAP measures to stabilize market and future incomes. We conclude that once the crisis abates, it will be necessary to reaffirm credible commitment and trust at all levels, not only with regard to production side but also on sale and distribution, especially in the face of changing consumption patterns that in the future will become more pressing for issues related to safety and sustainability.

Keywords: COVID-19, wine industry, pandemic, Italy.

1. INTRODUCTION

The Covid-19 Pandemic has triggered devastating consequences both for human lives and for economic progress. The most optimistic view of what we can expect after a long recovery from the COVID-19 will certainly be a half-full glass. The International Organization of Vine and Wine (OIV) sees in the near future a huge drop in wine consumption, as well as a reduction in average prices, and therefore in sales margins and turnover. The down-

ward pressure on prices could be even more pronounced for the fine wine market (the upper segment of the wine market) with a fall around 35% (Cardebat et al. 2020). While the Covid-19 pandemic has quickly delivered a global economic shock with catastrophic consequences, the increasing recessions in many countries and related trade uncertainties are affecting the entire wine sector, from production to distribution, sales, and consumption. The pandemic and the set of measures adopted to contain it, have led to massive downturns in global economies, and to increasing disruptions to global supply chains, trade that collapsed in the first half of 2020, and tourism for which the World Tourism Organization (UNWTO) has estimated a decline of 44% in international tourist arrivals with a loss of about 159 billion Euros just for the first quarter of 2020. Export found increasing difficulties and limitations alongside widespread international border closures, uncoordinated policy restrictions and social distancing measures, trade policy uncertainties and turmoil in the financial market (World Bank 2020a). Symmetrically Imports have been curtailed by aggressive quarantine measures, which heavily weighed on consumption and investment (World Bank, 2020b). Wine achieved a lower than average production volume in Europe, where the extraordinary measures to reduce the harvest volume had a significant impact in Italy, France, and Spain. But the sharpest decline was due to its heavy reliance on exports and tourism, in a magnitude that could jeopardies recent developments in most of the wine-producing countries. In Italy, Mediobanca (2020) estimated a loss of 2 billion euros in the 2020 turnover, resulting from a huge drop on sales between 20% and 25% compared to 2019. According to the Institute of Services for the Agricultural Food Market (ISMEA) from January to September 2020 wine export volumes are 2.6% lower than the previous year, while in value the loss is about 3.4%. Many priorities on political agendas previously considered ambitious, especially those related to the post-2020 CAP reform that aim at securing those investments necessary to align agriculture with Sustainable Development Goals (SDGs) risk now to become even further out of reach (Pomarici and Sardone, 2020). A huge question mark looms over the vast majority of emerging market and developing economies, the growth for many sectors is still uncertain, and even worse scenarios are possible if after the immediate policy support the structure of the wine industry takes longer to recover. The simple wage of this paper is to provide a reflection on the effects of the COVID-19 epidemic for the wine sector. Building on a Conditions-Strategies-Performance framework (Grando et al., 2020) adapted to the emergence of the COVID-19 pandemic the analysis integrates a desk-based review of recent economic perspects on the wine sector (World Bank, 2020a; Vergamini et al., 2019) with diverse experience data collected through two workshops conducted before the spread of the pandemic (Jan 2019) and during the first lockdown of May 2020. The purpose is to offer a critical reflection on the most-updated socio-economic narratives and policy implications, in the light of the current crisis. Distinguishing between short and long-term implications, we will try to analyze the impact of uncertainty that has spread since the earliest outbreaks of mid-March 2020 providing possible courses and outcomes. Clear policy actions and recommendations to alleviate the ongoing suffering of the sector are discussed, as well as addressing future challenges such as the recovery of the environmental investments through sustainable policies and the support of international trade through global coordination and cooperation. The starting point of our reasoning adapts well to the Italian sector and other traditional wine countries (France, Spain, Portugal), after which some trends and policy implications that are specific to the sector can also be extended globally.

2. METHODOLOGY

2.1 The Condition-Strategies-Performance (CSP) framework

The analysis provides a review and a reflection that further expand and test the CSP approach of Grando et al. (2020) derived from industrial organization (Porter, 1980) and agrofood value-chain management approaches (Rastoin and Ghersi, 2010) in light of the current spread of the COVID-19 Pandemic. The previous CSP framework was completed towards the end of 2019 in a completely different scenario. Driven by the objectives of the EU-funded Horizon 2020 SUFISA project[1] it has been tested on various sectors (Prosperi et al., 2019) including wine (Vergamini et al., 2018). However, the disruptive changes introduced with the pandemic in 2020 offered the opportunity to revise the previous approach and further develop the framework according to the mutated conditions. The framework proved to be a reliable ally for understanding the way the producer integrates and

[1] SUFISA – SUstainable FInance for Sustainable Agriculture and fisheries was an H2020 Project (Grant Agreement 63555) for which we analysed the wine sector in Tuscany through several quantitative and qualitative research activities. The National Report for Italy provides a synthesis of the diverse experience data we gathered through a survey, several focus groups and regional workshops (https://www.sufisa.eu/publications/, last accessed June 2020).

translates internal and external conditions into chosen strategies that then leads to performances and how on the basis of the observed performances producers adapt by recalibrating reactions to conditions (e.g. remote tasting, web-marketing, quantity of seasonal labour, etc.). Given its extreme flexibility, we have chosen the CSP approach to capture the short and long-term coronavirus pandemic effects on producers' strategies and performance in the wine sector. For ease of reading, we report here only the elements of novelty that are attributable to the changes introduced by the current crisis, while for more details regarding the CSP we remind to Grando et al. (2020). The adaptation of the CSP under the COVID-19 scenario is summarized in Figure 1 and should be interpreted in the following way. The core is the decision-making unit (the wineries). According to the change in external conditions introduced by the worsening of the pandemic (restrictions on the free movement of people and goods, trade and tourism disruptions, introduction of social distancing rules, national, regional and local lockdowns, rising of unemployment and financial stress), we observed a sudden change in the wine business environment, especially for the wineries that focus on the on-trade channels and those more export-oriented and widely connected to Global Value Chains (GVCs.). The shock induced by the change in external conditions has determined for wine producers the need to confront and subsequently adapt to a new – although initially perceived as temporary – internal environment.

While wine production conditions appeared stable in the short to medium run as producers have adapted to the situation and continued their work in the vineyards, others were the conditions that mostly constrained wine producers. The "new" internal environment was found to be characterized by a lack of timely policy measures and coordination, by the drop of on-trade channels against the growing concentration of large retailers and supermarkets, by a quick fall in consumption of fine wines vs an increase of the medium-low quality segment albeit with a strong focus on regional brands, by sudden labour shortage and an increase in production time and costs vs a drop in average grape prices, with a generalised lack of liquidity and increase in debt exposure and related risks. Both external and internal conditions constrained the producer's decision-making to produce timely and adaptive strategies while waiting for a wider structural policy support. These responses, as we will analyze more in detail below, have had an impact both in the short and medium-long run on the performance of the sector, according to differences in the composition of output and exports, as well as the endogenous factors that determine the competitive-

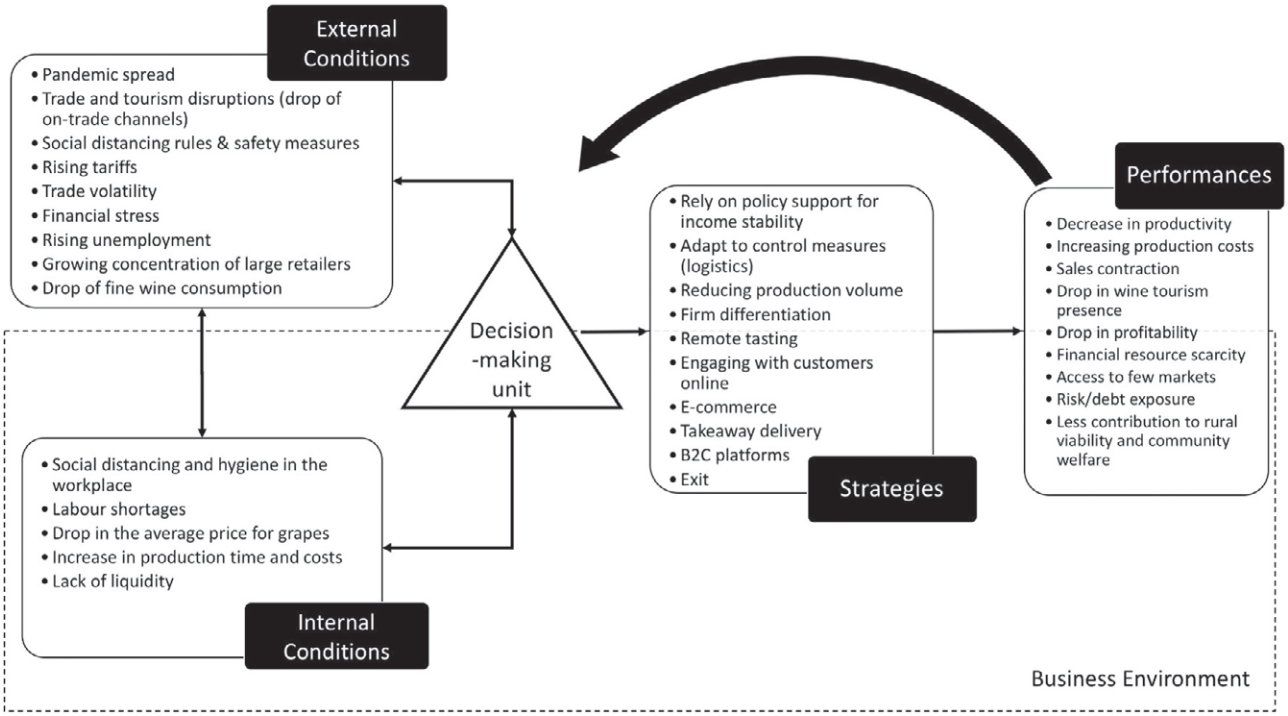

Figure 1. Producer's Decision-making Process. Source: Author created.

ness, the reliance on on-trade vs off-trade sale channels and producers' participation in GVCs.

2.2 Data collection, CSP development, and reflection

The process of reviewing and reflecting on the CSP approach in the light of the current pandemic crisis for the wine sector was based on a phased mixed-method participatory research process that integrated stakeholders' opinions, experiences, and reflections with a desk-based review of different sets of conditions, strategies, and performance at the end of 2019 with those in mid and late 2020 (Fig. 2).

We developed a baseline picture for the CSP analysis (i.e. the state of the sector before the pandemic) building on Vergamini et al. (2019, 2018) and integrating additional discussion elements grasped from a large workshop conducted in Tuscany during 2019 with 80 key players of the wine supply chain. The actors involved in this first workshop included small, medium-sized and large wineries, academics, members of DG-Agri of the Tuscany region, members of Tuscan PDO Consortia, sales agents, and other key intermediaries. In compliance with privacy issues, to these type of data, we will refer in the text with the initials WP (workshop participants). The workshop was organized as an iterative and interactive foresight game to capture the strategic nature of decision-making through a cyclical process of confronting potential future European wine sector states including agricultural and trade policies with individual and collective objectives, planning or taking future action (strategies), and reflecting on potential outcomes and policy implications (for a deeper analysis of the scenario building process[2] see Gardin et al., 2019). The experience data collected through the workshop contributed to develop and validate the chosen baseline set of conditions and strategies (see Annex 1). The actors involved answered questions about how they plan to meet these conditions or which strategies among those that can be implemented in the described scenarios they think can contribute to reaching individual and collective objectives regarding the future sustainability of the sector. Such exercise generate discussion among stakeholders that we further employed to validate, and, ultimately refine the baseline CSP.

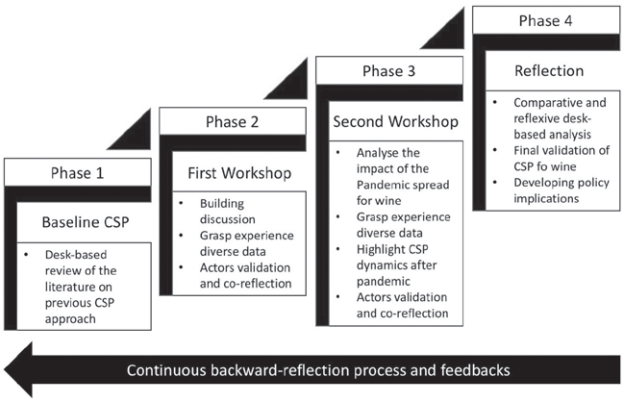

Figure 2. Phased mixed-method participatory research process. Source: Author created.

Then during the early outbreaks of May, we promoted a second and Web-based workshop (May 15, 2020) to co-reflect with more than 20 international wine actors across the supply chain (international winemakers, market consultants, agricultural consultants, wineries, representatives of regional institutions, academics and students) on the impact of the sudden changes in external conditions leaden by the pandemic on the producers' strategies and performances (please see Annex 2 for a deeper explanation of the workshop scopes and process). The data collected allows researcher to develop a backward reflection on the initial CSP set and grasp additional short-term implications for different geographical contexts (Italy, France, Spain, Portugal, Australia, and US). The workshop was intended to 'ground-truth' on the previous findings and better clarifying the role of the different pandemic stressor(s) in driving adjustment processes and the dynamics that drove wineries from the 'baseline CSP' in the past to the new framework with respect to the current pandemic state and to the future sustainability and viability of the sector.

Then a final comparative and reflexive desk-based analysis of market and regulatory conditions faced by the producers integrating different and recent economic prospects (World Bank, 2020a; OIV, 2020) was conducted by the research team to structure the different findings and provide key insights in terms of policy implications. Drawing on the different data sources described above, the next sections examines the resulting condition, strategies and performances, particularly in terms of different temporal (short vs long term) and spatial contexts, the pressures faced by producers in each region and the strategies adopted by wineries and associated supply-chain actors to adapt and overcome the pandemic.

[2] For ease of reading, it is important to mention that the scenario narratives were built on the basis of key dynamics that afflict European agriculture and which can be summarized in three macro-categories (consumption models, distribution of power along the supply chain, prevailing technological models) that resulted from the SUFISA project. For wine, the interaction of these macro-categories with different trends and drivers of change identified for the Tuscan sector led to the formation of potential specific reference scenarios that have been verified with actors under their territorial context.

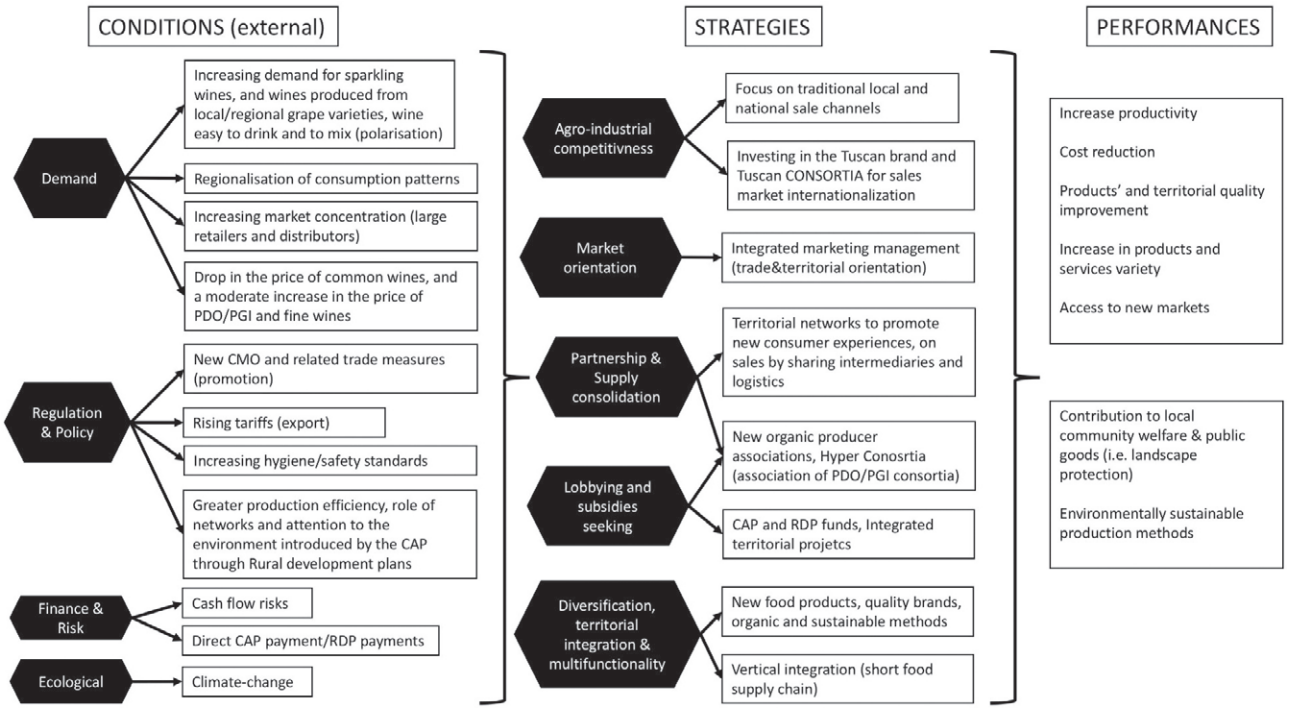

Figure 3. The baseline CSP framework for wine. Source: Revision on Grando et al. (2020).

3. A DEVASTATING BLOW TO AN ALREADY-FRAGILE VISION OF THE FUTURE

Before March 11 2020 we did not expect a certainly bright future, however, there were positive trends and strategies that aimed – let's say – to increase the sustainability of the sector (Obi et al., 2020). The baseline conceptual framework (Figure 3) illustrates that in face of growing concentration on foreign markets, rising tariffs, and regionalisation in consumption patterns, we have witnessed the consolidation of investments in traditional local and national sale channels, increasing investment in the maintenance of the territory (e.g. RDP non-productive investments aiming at securing environmental assets such as landscape through the restructuring of old and abandoned terraced vineyards) and in quality, the progressive formation of new territorial networks to promote new consumer experiences (Brunori et al., 2012), the growing application of trade marketing (spread of B2B and B2C events), and the improvement of existing facilities, especially those related to the increasing of wine tourism in the light of multifunctionality and income diversification. For some Italian regions like Tuscany, where the budget for CMO promotion measures is around 30 million euros, these investments represent the result of a decade of work conducted by the Region together with the regional wineries and protection consortia. Thanks to these efforts Tuscany gained its resonance as a global umbrella brand for its agricultural productions, including its high-quality wines (e.g. Chianti, Brunello di Montalcino etc.). However, these developments have not been limited to promotion but involved the transformation of the regional winescape (Vlahos, 2020). If climate change was a key concern, there was no lack of plans for sustainability and improvement of the vineyards. Indeed, the attention to sustainability and to the environmental impact of production have been proved, for example, by the widespread increase in organic viticulture (Pomarici and Sardone, 2020). In the panorama of sustainable initiatives, the Italian producers were the first to believe in new production protocols such as organic, which in 2019 marked its strong growth. Even against the changes in demand and consumption patterns, we have seen an increasing ability of Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) wines[3] to boost their average prices and an increasing interest in wines that are easy to drink, mix, with low alcoholic content, premium, with low environmental impact and with alternative packaging. Therefore, in the face of wine structural flows determined by change in the sector conditions

[3] We refer to those wines that belong to the art. 93 of the Regulation (EU) 1308/2013;

driven by internal and external forces, producers demonstrated their ability to find proactive and unison strategies to maintain substantial stability of the wine supply, increase productivity, reduce costs, increase in products variety and access to new markets (Vergamini et al., 2019; 2018).

According to Vergamini et al. (2018) their performances resulted from strategies for which potential demand, as well as supply and market risks, were perceived as intelligible and manageable and for which they developed adaptive/proactive responses. However, as they pointed out during the first workshop, there are also other factors that should have been considered, such as environmental conditions, for which the risk can assume an indefinite value, beyond their control. Unfortunately, this has been – shortly thereafter – confirmed by the rapid spread of COVID-19.

The early March outbreaks exposed us to the idea of a fragile future, but above all, they added an additional element that we didn't consider in the baseline approach, namely "time factor". Although aware of the existence of sudden and uncontrollable changes in external conditions, in all the wine scenarios that we analyzed during the first workshop (Garding et al., 2019) an important variable escaped from the control of the analysts as well as of respondents, and it was the "time response", or rather the speed in providing solutions. The astonishing speed and the scope of the pandemic crisis is unprecedented. Although in previous scenario analyses we consider the opportunity for sudden shocks, what we did not model was the need for the predisposition of quick policy strategy, or let's say at least timely.

> What we should learn from the current situation is to anticipate the crisis, we need to prepare us and instead of perpetuating the present living we should project ourselves towards the future. (WP01)

Despite the unprecedented policy support and the stringent control measures to mitigate the ongoing health and human costs and to support the near-term economic losses, the underlying policy strategy was "taking time", since policymakers were not prepared to deal with a severe public health crisis of this scope. Although this factor is not immediately evident, the lack of predisposition and coordination among policies is detrimental in the long term, leaving more room for the downturn consequences that we are now experiencing for wine and for many other sectors. Thus, the uncertainty associated with the lack of predisposition, becomes the starting point of our revision of the framework and the first fundamental insight from our reflection.

> We have lived to date in the complete lack of signs of restarting, in an atmosphere of uncertainty, in the lack of real planning for the sector (WP02)

If it is true that nobody imagined this scenario before January, nevertheless in the last few years some extreme and catastrophic events have taught us the need to predispose strategies to be able to tackle quick measures.

> Covid-19 epidemic should lead us to review the production world in a different way. (WP03)

A strong sustainable future needs timely and targeted policy interventions that reaffirms credible commitment to sustainable policies and predispose a new relationship with the environment. As we would deepen in the discussion, at European level, for example, Pomarici and Sardone (2020) illustrates that the post-2020 CAP reform there already includes preventive instruments that goes in this direction like the "harvest insurance", the "mutual funds" and the "green harvesting". However, to these policy tools that could offer concrete stability to crisis situations, the Members States (MS) posed so far very little attention despite being feasible (Trestini et al. 2017). Before the COVID-19 crisis, the world was concerned with concentrating the National Support Programs (NSPs) resources on fostering competitiveness. Consequently, the overall picture leaves no room for optimism. In the next section, we try to analyze the events step by step to distinguish some key implications between the short and medium-long term.

4. SHORT-TERM IMPLICATIONS

In the short term, the wine sector – affected by social distancing and the tourism stop – experienced a sharper decline.

> The territories that before the crisis were growing, are now in difficulty, affected by the HoReCa stop and by the collapse of wine tourism. (WP04)

However, specific results emerge, reflecting differences in the composition of output and exports, as well as the reliance on on-trade vs off-trade sale channels and changes in those endogenous factors that determine the competitiveness (i.e. human capital and other terroir factors[4]). Portugal wines, for example, suffered a

[4] For a deeper analysis of the regional factors that determine competitiveness of the wine supply chain we refer to Vergamini et al., (2019).

lower impact than France, while the France sector has been affected more than the Italian one (Table 1), bringing out also the problem of different speeds for different countries.

In addition, the World Bank reports that the sectors that participate more in the global value chains could be more affected by the disruptive effects of COVID-19. Although wine is a territorially-based product, for those wineries that focus on export and are globally connected, the effect of safety measures is to slow down production and transport with the consequent lack of the necessary inputs/outputs between one process and another.

> Argentina, for example, encountered such a problem during the harvest with regards to labor shortage, since workers traditionally come from regions very distant from the wine-growing areas. (WP08)

The covid-19 hit the wine sector manly form the supply side. The wineries are not experienced with labor shortages as in other sectors. Since most of the labor force is generally mobilized during the harvest, producers from the southern hemisphere faced this problem during the first wave, while the European countries fear to face it with a second wave, which this time would bring down the resilience of the sector. In addition, the propagation of shocks through networks and trade interlinkages such as GVCs could be a major driver of economic fluctuations (Acemoglu, Akcigit, and Kerr 2015). GVCs account for more than half of global trade, which becomes more volatile especially during crises (Freund 2009; Taglioni and Zavack 2016). These effects could also prove disruptive for those companies that depend to a greater extent on external financial flows from companies operating in other sectors or that are simply controlled by foreign capitals. Wine has experienced a high degree of financialisation in recent years, where external investment and acquisitions have not excluded many popular brands.

Net of these considerations, in the supply chain of the traditional wine countries most of the "on-trade" distribution channels disappeared. The HoReCa and other "on-trade" channels have been the most affected by the lockdown. With the closure of restaurants, the stop of social life, travel & leisure industry, we assisted to the collapse of sales for many of the EU denominations of origin and other regional wines (i.e. the most affected). According to the Comité européen des entreprises vins (CEEV), in Europe the stop to this channel could lead to a 35% drop in sales volumes, and a loss of over 50 % in value. But let's not forget that the spatial dimension also matters (Ilbery et al., 2010). By unpacking this impact following a vertical direction (northern vs southern hemisphere) we envisage greater repercussions in the Mediterranean area where there is a greater concentration of wine bars and restaurants (Italy, Portugal, Spain, France and Greece). Furthermore, this area has seen in recent years the greatest concentration of investments in the vineyard and cellars: to improve the product quality, but also the appeal and accommodation capabilities of the territory.

> With regard to the hospitality in the north of Montalcino (Tuscany) we suffered a big blow, a devastating impact: we miss the most beautiful moment of our work, the relational one. If we consider also the contraction of the highly developed tourism industry, which will continue to be severely limited during the next months, the negative impact for thousands of wineries that focus on the strategic combination of these activities is likely to be unsustainable. (WP11)

The feeling is that the crisis is eroding decades of development standards for our quality wines providing unbalanced territorial consequences that could threaten the current objectives of a "vibrant agriculture" and "generational renewal" (Pomarici and Sardone, 2020). Although even before the pandemic several experts and practitioners endorsed several pessimistic scenarios for future wine demand, a general collapse of the market was truly unpredictable. On the opposite, considering only the increase in sales for domestic consumption mainly recorded by large retailers during the lockdown as a signal of recovery, we risk drawing wrong conclusions. In supermarkets, the offer is much more limited compared to the on-trade channels for which differentiation is a key strategy (Vergamini et al., 2019), and focuses on price and rather homogeneous products among several major players. According to Cardebat et al. (2020) we should contextualise the increase in sale of large distribution by market segments and distinguishing between export and national/regional market accounting for the collapse of off-trade channels. Therefore, we envisage that the most affected producers are those that a) focus on terroir-driven and fine wines, b) are based on export c) benefit from an important local/regional demand through HoReCa. The same reasoning applies to the rapid growth of sales in e-commerce. As we will discuss later with regard to the medium-long term, this type of offer is also badly suited for a highly differentiated production like that we are used to finding in the most prominent Italian wine regions.

> Ours is a medium-sized family business, for which the impact on the European markets has been violent, but we are mostly affected by the stop of HoReCa; Our winery has now realized above all his vocation and the link with

Table 1. Short-term implications by Countries.

Countries	Composition of output and export, on-trade vs off-trade, competitivness	Short-term implications	Impact experienced	Actors
Italy (Tuscany)	World class red wines (Sangiovese), export oriented, great focus on wine tourism, quite heterogeneous reliance on different trade channels (mix of on-tade vs off-trade). Strong territorial endowment.	With the collapse of wine tourism, the sector experienced a huge drop exacerbating the previous criticalities like late payments and increasing lack of liquidity. As a consequence, debt exposure is rising. Unlike France, before the pandemic, Italy managed to exploit the rise of United States tariff to its advantage, so the subsequent lock-down resulted in a balance of losses compared to the previous positive export balance.	Medium-strong	WP05
Spain (Rioja)	World class red wines, great focus on on-trade. Strong image of the regional brand.	In Spain, there has been a huge drop in wine consumption as in other countries following the HoReCa stop, which has mainly affected the upper tiers of production (40% nationally and 60% from the Rioja where they produce 300 MLN of liters/year of which 60% goes to the national market and 40% is exported). While the top wines recorded the major negative consequences, the consumption of medium-level or low-quality wine has increased, but with a very low percentage that does not compensate for the losses related to the closure of the restaurants. The estimation is about 40/50% reduction in volume and 50/60% in value (turnover). Last year the average price for grapes was around 1 euro/kg, while for this year predictions show about 0.5 euros per kg. In addition, several large processors risk purchasing less quantity. Even in Spain, there is a consensus for a reduction in yields, but without aids, part of the grapes will remain in the countryside. The impact of e-commerce was minimal but still a stimulus for many wineries. Tourism has had the first and greatest impact, now is the turn for uncertainty and the consequent economic crisis.	Medium-strong	WP06
Portugal (Lisbon)	Export oriented, great focus on wine tourism, mixed trade channels.	In Portugal, the main impact is on export; 15-20% losses for large companies and up to 50% for small wineries; Anyway, the export is gradually restarting with the reopening of the Asian, US and Canada's markets (with a probable increase of 15% of exportation); However, it needs to be balanced with the negative impact from the closure of HoReCa channels and the stop of wine tourism. Take-away and supermarkets contribute to maintaining sales while wine consumption at home increases. The feeling is that for the 2020 harvest in Portugal the price of the grapes will not be affected by the situation; Portuguese government has planned fiscal and support intervention with the same measure announced for Italy (distillation aid, etc.)	Low-medium	WP07
France (Bordeaux)	World class red wines (Cabernet-sauvignon & Merlot) and champagne (luxury segment). Great focus on wine tourism. Strong territorial endowment.	Restrictions played a major role in delivering less consumption of premium wine or luxury products like champagne while there was an increase in the consumption of cheap products; Wine region like Bordeaux has been mostly affected by the stop of wine tourism. Although the wine is a durable product, the situation doesn't encourage a reactive response from the markets when it will improve. Then the emotional context constrained the purchasing behavior; In addition, the confinement of workforces caused workforces troubles or increasing production times and costs. With regard to export, it decreased by 20% during the first 2020 quarter following another 20% fall just in march. Exceptional measures from the Agricultural minister provide: social security contributions for employees and companies with an envelope of 400 MLN Euros; Aid for distillation to reduce a volume of 2MLN Hectoliters with 140 MLN euros;	High	WP08
Australia (Adelaide Hills)	Great Wine Capital for white wines (Sauvignon Blanc), notably sparkling wine. Focus on export. Focus on drinkability and new blends (vanguard wines). The territory is a matrix of new and old patterns that aim at increasing wine tourism.	Limited implications since Vine harvest and Wine processes have been taken place normally with an impact on the organization and logistic steps due to social distancing restrictions; Restrictions slow down production processes while wineries react by engaging with customers online; for large wineries with 24hrs processes the impact was in the re-organizing of the processes (slow down, divided into steps with breaks to include regular cleaning processes) to reduce workers exposition to contamination; Large impact by the stop of travels; stop of wine tasting (no visitors) and shut down of HoReCa channels; Fires have been a greater concern than the Covid-19 shut-down; the main challenge is how they will maintain export channels (50/60% of their sales to countries overseas).	Low-medium	WP09

Countries	Composition of output and export, on-trade vs off-trade, competitivness	Short-term implications	Impact experienced	Actors
US (Napa Valley)	World class red wines (Cabernet-sauvignon). Focus on on-trade and wine tourism. The territory focuses on innovation and in the ability of renovating old blend and developing new and easy to mix and drink wines.	The US experienced border closures and various levels of strictness depending on the county level (yellow counties start later wearing masks etc.). During the lock-down, wineries were open without tasting, so with a huge economic impact for those areas like Napa Valley where tasting tours and on-sale channels are key. Off-farm sales were up, while On-farm or direct sales were down (retailers like supermarkets have increased their sales and considering a large amount of stock wine from past years this may help of clearing past inventory). This, however, does not represent a trend that might continue with the reopening. It seems that when people stuck at home they increased wine consumption or simply since they cannot consume wine outside they substitute with in house consumption. For smaller companies high-end, high-quality producers are facing huge economic difficulties (potential bankruptcy in the next few months) and it really depends on how quickly restaurants will be re-open.	Medium-strong	WP10

the restaurants despite having a couple of multi-channel labels including those suited for large retailers and supermarkets, which obviously continued to sell in this period in Italy and abroad and the online channel worked a bit; but lacking tasting or direct-sale, we feel worried. If uncertainty was initially normal, it is now becoming chronic and widespread across Europe. We will invest in online but we believe in returning to a vis-a-vis relationship, wine needs relationships. (WP12)

In line with the relational nature of wine, we feel strong doubts about the possibility of shifting our business online. We need certain and quick answers on the public front to support tourism, the author's cellar is in great difficulty. It needs support and speed. (WP13)

In any case, even in face of considerable growth in e-commerce and takeaways, the profitability of producers who relied on more traditional channels remains deeply undermined. Neither large cooperatives escaped from these negative effects, especially those direct-selling/regional based that in the last decade have made substantial investments to shift their business towards PDO, organic, and terroir-driven wines. In the same way, we risk being exaggerated to figure a general collapse of the market, since a recent Mediobanca survey confirms that 53.4% of the cooperatives that focuses on "off-trade" channels, expect for 2020 less pessimistic results. Furthermore, for Mediobanca the Italian wine could lose up to € 2 billion in revenues in 2020, with a drop between 20 and 25 percent compared to the 2019 (a great year).

Assuming that the COVID-19 specific effects on exports come on top of the fall in world trade envisaged by the World Trade Organization (WTO), current projections estimate a contraction in exports between 700 million and 1.4 billion Euros for the major Italian producers in 2020. With regard to the domestic market, given that around 65% of national sales are "on-trade", the short-term impact can be approximated to a loss of over 500 million Euros. This figure is also confirmed by the recent Nomisma Wine Monitor survey. According to the results of the first quarter of 2020, considering the US market, the sales of Italian wines in the off-trade reached 94 million liters, which represent only 40% of the total imports. The problem will therefore concern the other 60% of Italian wine for which we expect a drop, especially with the on-trade that is continuing to be down to zero. These observations, coupled with the fact that liquidity is quickly drying up on the wine market reinforce the thesis that the latter segment is the one who in the end will have suffered a devastating blow. A survey on 400 producers recently conducted by Firab (Foundation Italian for research in organic and biodynamic agriculture) found that the 73% of organic farms were hit by the pandemic crisis and, in terms of liquidity for the 65% the expected economic stability is at most three months. To notice that half of the respondents is under 50 thousand euros in turnover. These figures corroborate the narratives expressed by the Italian producers who attended the second and "online" workshop. However, as we introduced in Table 1 the past quarter did not end entirely in a negative way. Indeed, thanks to the threat of tariffs and the "January exploit" of Italian wine in the USA, the Italian trend was above the average of the other countries: overall US imports for the quarter closed at + 10.9% in value. Therefore, net of exogenous and external factors (tariffs and covid-19) it is now necessary to shift the discussion on the medium-long term.

5. LONG-TERM IMPLICATIONS

Severe and long-lasting socio-economic effects of the pandemic crisis may erode the basis of a balanced territorial development and rural viability. The decline in investment because of elevated uncertainty and financial stress, the ruptures in trade linkages, the fall of many businesses, and the rising unemployment will cause negative effect on both consumers and producers sides. In addition, potential difficulties in providing a continuum of specific support programs to existing declining agricultural areas and to those segments hit by the COVID-19 crisis (the more dependent by the on-trade channels) risk compromising the human and territorial capital and losing a whole series of necessary assets for terroir-driven wine regions, such as the protection of landscapes and environmental quality According to World Bank (2020a) the economic, social and environmental implications are likely to be more severe and protracted in those countries that experienced larger outbreaks, greater exposure to international spillovers (i.e. GVCs, financial markets, and tourism), and pre-existing difficulties such as business and workers informality, large flaws in the health system, widespread social inequalities.

Furthermore, the COVID-19 epidemic eroded the confidence about prospects for future labor income and profits, in other words, it contributes to a widespread uncertainty forcing wineries to operate with weak cash flow in a generalized lack of liquidity (Figure 4). In the medium- and long-term the wine risks continuing to be penalized by psychological aspects, linked to the general climate of uncertainty. We could introduce it as "domino effect". The collapse of economies in the short run caused a sharp decline in household consumption and firms' investments with huge repercussions on demand and supply (Bhandari, Borovicka, and Ho 2019). Recession and subsequent increasing unemployment caused a loss in lifetime earnings, but to a greater extent the risk of unemployment permanently increases consumers' savings rate, while again reducing consumption.

> Tourism has had the greatest impact with the collapse, and doubts are still strong. There is a growing concern about the economic crisis that will come. Actually, we have 5 million workers at home that have been supported by the Spanish government, which will have an impact in the medium and long term on the GDP. What about unemployment? Now is likely to be at 20%, and in the next future? (WP06)

In this scenario, a key point will be the economic health of "on-trade" players and their attitude towards risk. In the worst case by becoming risk-averse the HoReCa players will make fewer orders, asking for more delayed forms of payment to minimize their risks (the participants' behaviour affect pricing and buying dynamics).

> In the short term, we took care of the cellars, how to keep them in business, while in the long run we must support our distributors. (WP12)

Accordingly, the wineries that focus on the on-trade channels will be crushed between the reduction in sales and downward pressure on prices, in any case, with less liquidity.

However, among the PDOs, PGIs and fine products, each wine will make its own story (evidence suggest a drop on price for Chianti wines). Many reactions from several wine regions will depend on the combination of creativity, innovation and their ability to deal with political risk (Cardebat et al., 2020). But probably to curb the slow decrease in the price lists the wineries will need signs of a strong recovery, especially from travel & leisure industry.

> Considering that Tuscany has 38 million tourists, as strong sign towards recovery we should focus on rural tourism as a guarantee of accompaniment (strong sign) towards recovery. Rural tourism could be a much safer or more manageable form of tourism. For example, we should develop partnerships between restaurants and wineries to shift the restaurant from the crowded city centers to the rural areas, in those structures that could allow greater control and security. (WP13)

At the opposite for some large brands, the situation will be probably more affordable since they could be able to impose higher purchase quantities thanks to their greater market power "in a take it or leave it way", while the others will be forced to find new creative solutions (i.e. social networks, e-commerce platforms) or in the worst cases to exit the business. While a probable future in the face of the appropriate incentives for distillation, could then see the ***distillation of wine surpluses***, possibly to produce sanitizing alcohol and help unprofitable firms to persist (we analyze the implication in the discussion), the first overall impact for the sector in the medium-long term is that of the ***consolidation of a two-speed market***: one driven by large retailers and one by the slow restart of the on-trade channels. Potential impacts from this situation vary greatly in function of the opening and participation of wine regions in GVCs and from the rebound velocity for those small and medium direct-selling and terroir-driven wineries. In a post-Covid-19 world that support open trade with exchange rate stability the local tropism could be a limiting factor. Wine region as well as wineries that are

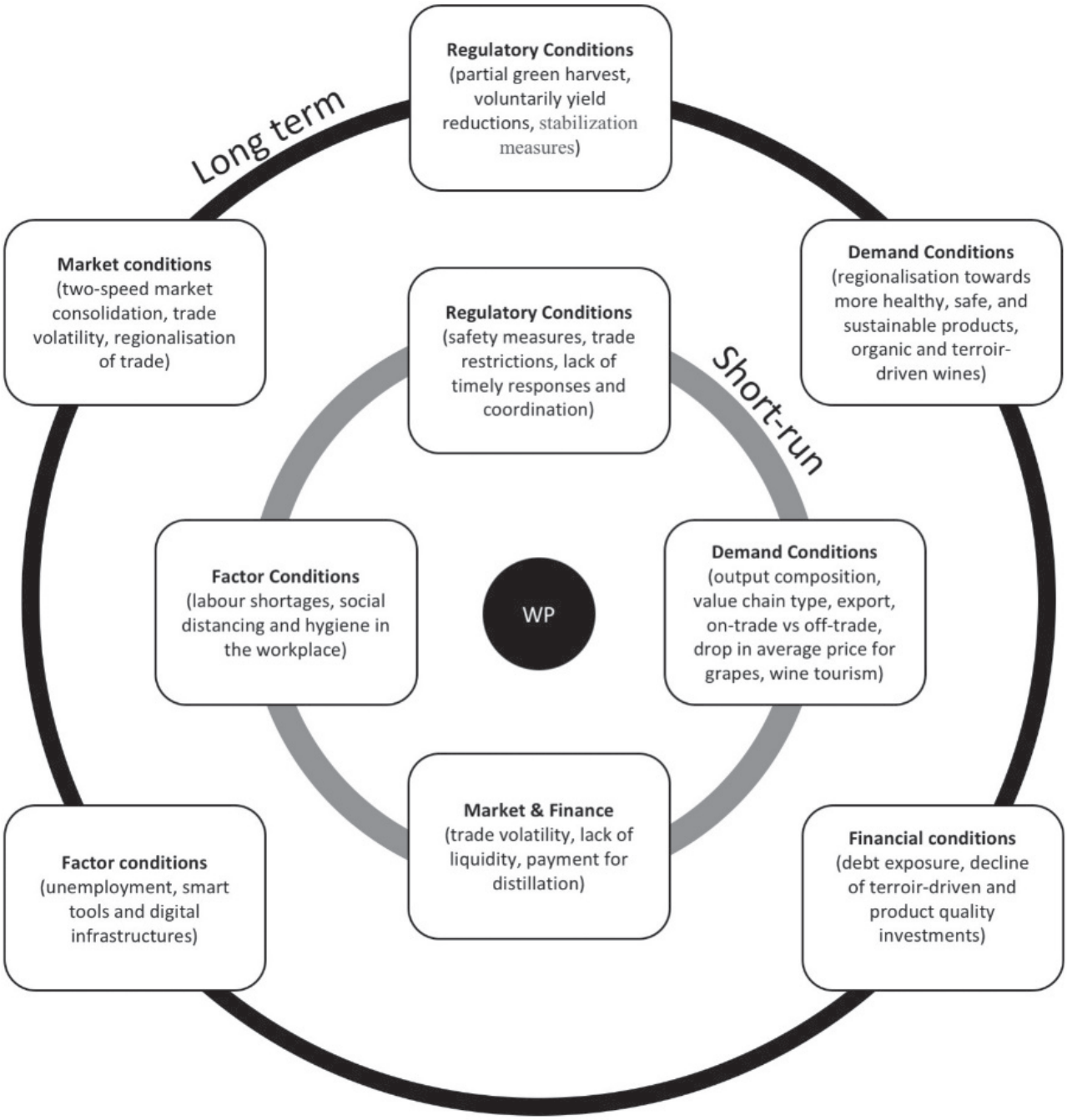

Figure 4. Validated short- and long-term wine conditions. Source: Revision on Grando et al. (2020).

well-integrated in GVCs may re-assess whether the gains from participation in global value chains are worth the risk of further disruptions. A retreat from these export-oriented firms towards a regionalization of trade would produce adverse effects on the sector (Barattieri et al., 2019), further reducing already-low growth and productivity. In the latter, the main threats are the permanent loss of productivity for many wineries and the risk for the wine territories of being depleted of all those investments necessary to maintain quality, and most important to secure the necessary environmental interventions (let's not forget that during 2019, many wineries have made great investments to deal with environmental improvements). Vice-versa in a protectionist context and

strong exchange rate instability due to tripartite trade war between the U.S., China and the European Union the regionalisation of trade patterns become a key success factor due to strategic trade policy reasons but also for solid local direct-selling dynamics.

In both cases we can expect a drop of investments (except in communication) and ***more control of yields during the harvest.***

> too much wine on the market risk to eliminate the value of the supply chain. (WP15)

Then, despite near-term policy support, some wineries will resort to credit or financial strategies to survive given the supposed 'safe-haven' nature of their wines.

> At national level, under the caring for Italy decree of March it emerges the revolving pledge as an instrument that gives wineries that have stocks of wine the opportunity of depositing such value to the bank as a guarantee on the loan. Furthermore, when wineries will sell the wine they replace the guarantee with other lots to keep the bank guaranteed. This instrument will be very valuable for Italian PDOs' wines. (WP14)

However, net of any short-term private/public aid, we refer to a second and most probable medium/long-term effect as the "**financial stress**", whose balance will depend for the European wineries to a large extent on the availability and access to the future CMO/RDP measures and other forms of more structural support provided by the post-2020 CAP reform (Pomarici and Sardone, 2020). In addition, export-oriented firms tend to be more exposed since they are dependent on borrowing to finance promotion activities and trade marketing. For all the wineries that are in financial stress the inability to service debt (high borrowing costs against weak cash flow) could cause to exit the business. More or less evidently, a third effect of the COVID-19 epidemic will be the **greater attention to digital**. While e-commerce, smart work, and remote technologies did not allow the wineries to balance the negative impact of the fall in sales, several wineries are investing more in digital, both for the marketing of products and for export processes.

> Coronavirus has accelerated these new horizons, and we expect that the newly opened channels will also continue when the sector restart. In our opinion, those who bought on the web will continue if they have had a positive experience, a key aspect for future business. (WP05)

> During the lock-down we started to focus on the online channels; We implemented a new customer management system (CRM) and we tailored our newsletter, the frequency of which has increased thanks to increasingly personalized CRM management. There has been a positive response from the US as a market more accustomed to actively participate in virtual life vs the Italian market that is almost at a standstill. We created a virtual wine experience, bookable online. Literally we bring at your home the Val d'Orcia. The experience consists of a "home delivery" of a tasting kit with all the accessories necessary for a classic tasting with the addition of a virtual tour at the vineyard, cellar etc. and with a final guided tasting. However, it is difficult to create emotions and empathy even if these virtual experiences will increase in the future. (WP11)

However, the different experiences converge on the difficulties to completely transfer the emotional/relational nature of wine consumption to a virtual environment. Without policy intervention, most wineries see the risk of privileging quantity rather than quality, rewarding again the large networks or at least the more structured companies. However, policies could play a crucial role in supporting this transition. If on the one hand, the producers try to be resilient, in the long run, and without policy intervention, the situation risks exacerbating negative aspects of current changes in lifestyles and consequently in wine consumption.

Finally, a fourth and very likely change will be delivered by **new consumption patterns**. Today it is difficult to determine whether in the future we will see a greater role for "safe" and environmentally friendly products, but for producers, the challenge of organic and terroir-driven products represents a key opportunity.

> Wine will benefit a lot when people come back to life and relationships, as a product that focuses on these aspects. However, the consumer patterns will change focusing more on sustainability. If before the Covid-19 epidemic, words like sustainability, authenticity, and transparency were often associated with empty slogans, with the crisis the consumer's attention to their contents could increase. (WP05)

According to future societal demands, the current crisis offers a further opportunity to strengthen the greening process of the CAP promoting behavioural shifts in line with the recent Green New Deal by the European Commission, and follow up initiatives (e.g., Farm to Fork strategy and Biodiversity strategy).

6. POLICY IMPLICATIONS AND CONCLUSION

We analyzed the consequences of the COVID-19 outbreak on wine sector building on a tailored revision of the CSP framework of Grando et al. (2020) that allowed us to integrate diverse experience data with

recent socio-economic narratives bringing out key elements for short and long-term policy implications. According to our review, the most prominent economic narratives support that despite an arsenal of macro-prudential support policies in the near term the pandemic caused the disruption of domestic demand and supply, trade, and finance. The speed and depth with which it has struck the sector depends on the microstructure of the wine and suggest the possibility of a slow recovery that poses formidable challenges for policymakers.

According to World Bank (2020a) protectionism in the way of new trade restrictions should be avoided since it could reverse the few gains that the sector maintained (i.e. by increasing price volatility and dampen growth) and it does not offer a solution to the security problem. To limit probable long-term negative implications, the analysis underscores the value of coordination and cooperation in agricultural policy as well as between and across governments and the private sector. The diverse opinions collected through the online workshop converged on the need for greater coordination between regions and the national government in planning income stabilization measures. For the Italian sector, despite the envelope announced of approximately 50 million euros, the reduction of stocks through "a distillation of crisis" for the participants risks of not generating the desired impact since it focuses on "generic grapes" a quality that is now becoming marginal in many regional vineyards (i.e. in Tuscany generic grapes weigh only 1% of the total at the national level). By extending this reflection beyond the short term, especially in view of its further application in the field of measures to target market and revenue stabilization within the CAP reform, this tool should be refined according to the principle of complementarity to provide a better use of available funds per MS and a balanced achievement of its outcomes. Despite the new CAP was designed within a very different scenario the challenge for policymakers will be to integrate the urgent interventions with the long-term measures to reshape the structure of the EU wine industry after the pandemic. Thus, the crisis offers a new opportunity for strategic planning that should likely facilitate this process. Therefore, in the wine sector, the debate converges on the opportunity to implement ad hoc strategies and combining the different available tools. The same reflection applies to the "partial green harvest" or the voluntary reduction of yields that will be part of the stabilization package discussed for the post-2020 CAP reform. The application of this tool should provide a quick-fix in the current situation, but for its effectiveness, in the medium-long term, there are at least a couple of points that need to be further analyzed. The first regards the attention and the resources that will be effectively delivered because in the past they have been always very scarce (Pomarici and Sardone, 2020; European Commission 2017). As we previously introduced in the past the MSs took advantage of favorable wine market conditions to concentrate NSPs resources on fostering competitiveness, while we expect that the green harvesting, insurances, and mutual funds should assume more importance in the next future, especially after the current shock. Again, the crisis could represent the opportunity to reflect if it is necessary to implement complementary actions that facilitate the effective adoption of such tools. The second point stresses again the need for more coordination between policy levels. In face of the recent regional advance in securing quality and the origin, the key message is that "centralization could be risky" since there are regions that are more advanced than the national government in the control of vine and wine-growing potential. These actors fear a limited impact of a "complex aid" that should also guarantee "speed, effectiveness, and simplicity" at the same time.

One positive aspect that emerged is that the COVID-19 epidemic increased the solidarity between supply chain members and amplified the opportunity for discussion, shifting the attention from a crystallized present towards the search for a viable future that should go beyond the current limits of the sector in a more effective way. Consistent with this idea, one option could be on dusting off old CAP tools. We refer to the open debate on the single CMO on the integration of wine actors (European Commission 2016). Indeed, forms of aggregation such as producer organizations (POs), which are not currently widespread in the sector are seen as a strategic instrument in concentrating supply, obtaining more favorable prices that notwithstanding the rules of the European competition, facilitating the access to CAP support and deliver a significant reduction in production and marketing costs for their members.

With regards to the single CMO, it will be relevant to provide the necessary support and flexibility for securing the ongoing projects for the restructuring of vineyards and promotion, which are key measures to guarantee the viability of wine territories, especially for those actors that have been most affected by the on-trade fall. Thus, policymakers should provide quick reprogramming. For example, the Tuscany Region is now acting as a facilitator with the national government to allow an extension for the NSP to the conclusion of the projects (March 2021), as well as a fast and smart variant, to ensure promotion actions (e.g. no Vinitaly, it is possible to steer the promotion action in ultra-rapid times in other markets), an increase the percentage of contribution from 50 to 60 percent (i.e. less promotional activities but with the same

budget) as well as a reduction of penalties. In line with these needs, the future CAP could include – beyond the typical promotional actions and market analysis – new actions aimed at the preparation of technical files and facilitate access to non-EU markets with information on oenological practices limitations, phytosanitary and hygiene rules (Pomarici and Sardone, 2020).

If the problem of the future has repeatedly stressed by participants since the crisis is seen as an opportunity for redemption, then the need to limit future shocks becomes crucial. Despite the unprecedented amount of financial support to "do whatever is necessary to restore confidence and economic growth and to protect jobs, businesses, and the resilience of the financial system" (U.S. Department of the Treasury 2020), the need to invest in the predisposition of viable future strategies and policy interventions emerges from the discussion. In other words, against an immediate support strategy that shift the private sector income losses into public debt relaxing capital and liquidity coverage requirements, a more direct role of policies is expected to ensure a strong and sustainable economic recovery of the territories, evaluating the opportunity to support the investments, human and territorial capital. However, to achieve these goals, it is necessary to recover a climate of trust, starting from the travel & leisure industry. Many Euro Area members that are heavily reliant on tourism, are still prone to a slow recovery, stressing the need for more cooperation. Wine as many other sectors will need to uphold a stable rules-based international trading system to secure a solid and lasting recovery. Although the COVID-19 epidemic has caused the disruption of the most privileged on-trade sales channels, the sector has witnessed a new ability to coordinate among the various actors to express positive messages of restart, identity, and reaffirmation. This positive wave has also offered an opportunity to accelerate the process of consolidation of the supply-chain (Vergamini et al., 2019), at least for what regards the formation of new promotion networks at the regional and national level. The most important Italian wine Consortia are now acting in this direction. For example, the Chianti Wine Consortium launched a European tender to form a network aimed at developing promotion in Canada and the United States. From this point of view, the ability to network resources, at least for promotion, could represent a fundamental element to overcome growing difficulties. In addition, to facilitate this type of operation, several Italian regions are requesting a variation on the NSP to offer the necessary support to alternative forms of promotion like remote tasting or virtual B2B meetings.

Finally, the pandemic poses the production of healthy, safe, and sustainable products as a key challenge for many wineries, representing what we can see as the half-full glass.

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ANNEX 1

SUFISA Regional Workshop: "Long-term future scenarios of wine markets between opportunities and risks: what will be the strategic choices of Tuscan wineries"

a) Objectives of participatory scenario workshop

The participatory workshop was the final task of the SUFISA activities for WP4 "Scenarios & Solutions" carried out by the University of Pisa. The workshop intended to elicit the views and opinions of relevant stakeholders and decision-makers operating in the Tuscan wine sector. The end goal of this event was the identification of market and regulatory issues influencing the performance of wineries in Tuscany (Italy) in response to potential future scenarios (see Gardin et al., 2019 for a deeper understanding of the scenarios development process); to elicit how wineries developed strategies to deal with them and to discuss their relevance for the sustainability of their farms and farming systems. More specifically, the aim was to extend, support with further evidence, and refine our understanding of CSP framework from a primary producer perspective, and contribute to the formulation of future alternative solutions. Accordingly, the workshop was organised as an interactive cyclical process of ask & answer at an individual and collective level (work in groups) between researchers and 38 participants (small and medium-sized Tuscan wineries, wine cooperatives members, staff members of the Tuscan DG-Agri, wine consultants and extension service providers, members of the special agency of the chamber of commerce "Promo Firenze"). In other word, the workshop triggered participants to confront potential future European wine sector scenarios including agricultural and trade policies with individual and collective objectives, planning or taking future action (strategies), and reflecting on potential outcomes and policy implications.

Before the workshop, we engaged participants by email, sharing all the relevant information about the SUFISA project and its related scenarios, as well as the workshop goals and its schedule.

b) General introduction: presenting the four food system narratives (scenarios) and their (possible) impacts for the wine sector

Since wine significantly differed from the other SUFISA sectors and commodities, before the running of the regional workshop we discussed and refined through several face-to-face meetings with relevant regional stakeholders (members of Wine appellation consortia, of wine cooperatives, large regional wineries, as well as members of the Tuscan DG-Agri) the four scenarios

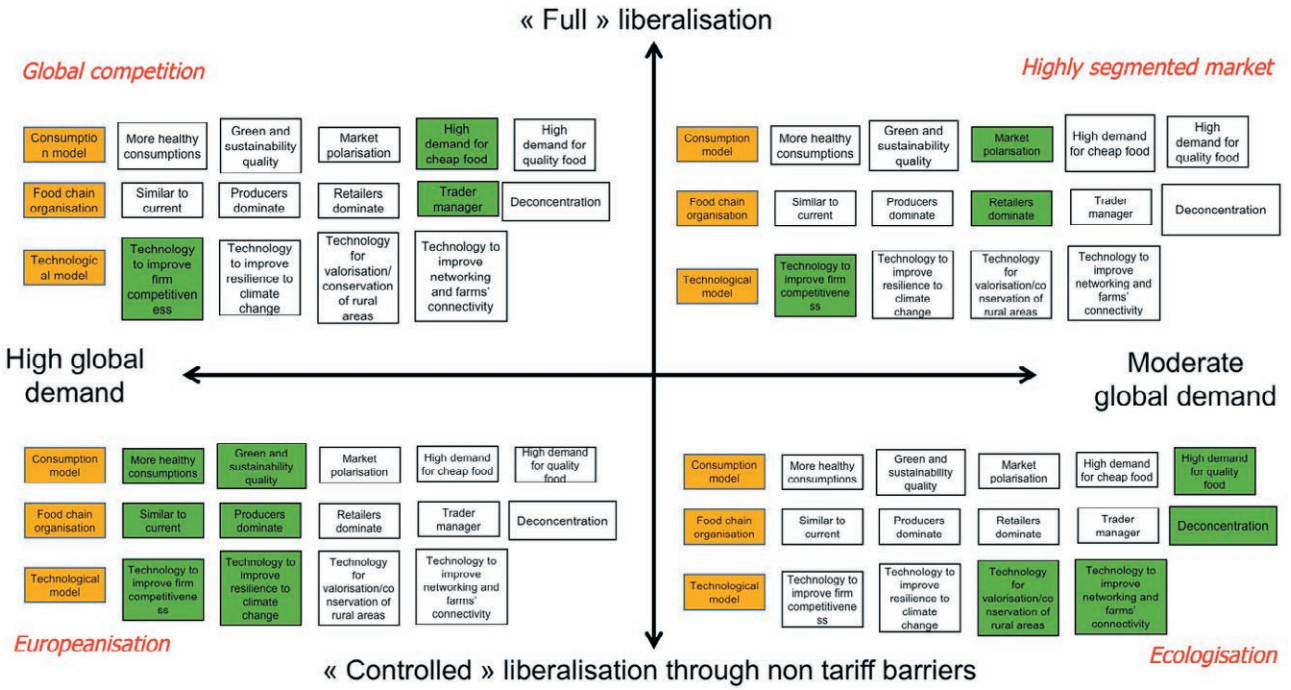

Figure 1a. Four scenarios for Tuscan wine sector.

provided by the SUFISA project in order to adapt it to the different specificities of the wine sector. Below we report the resulting scenarios. Figure 2 summarises the main variables and trends and it follows a brief description for each scenario.

– Scenario 1: International/Global competition

The first scenario (international competition) is qualified by an overall increase in demand as well as full market liberalisation. To 2030 it is assumed that the dominant consumption model is based on low price and cheap food due to a limited amount of household budget for the food basket. Wines of medium-low quality and reasonably priced are now globally available thanks to the modern trade. The consumption of premium and organic wines has been limited to few segments of the average richest population, among these, consumers continue to prefer to drink less but of more quality. Therefore, on average consumers are not willing to pay for quality products and low-price food is ensured by trade. The wine trade is completely liberalized and both tariff or non-tariff barriers are removed. There is less bureaucracy with a marginal weight of product standards lower than in previous years (i.e. less stringent rules for labelling and fewer controls). The dominant research is mainly performed by few private corporations that – due to a huge investment in the sectors as well as dominant position in acquiring farm data – provide new technologies and equipment mainly aimed at reducing production costs. The control of all farm data together with the advanced use of digitalisation and big data allows such few multinationals to directly support farms in any daily practices to reduce production costs. Thus, the market has become very efficient but there is a very high competition among farms (many small and medium-sized farms have stopped producing wine) and just few farms can still afford to produce premium and organic wines. The value chain is dominated by intermediaries (international buyer and export manager) with a very low bargain power for both retailers and producers.

– Scenario 2: Highly segmented market

The second scenario (highly segmented market) is qualified by an overall reduction in the demand as well as full market liberalisation. The reduction of the demand mostly affects the cheapest segments of production (standard and table wines). Thus, within the market, both cheap wine and high-quality wine (premium and organic wines) coexist. Consumption is increasingly regionalised, the differentiation of production undergoes a considerable increase, the types of quality products increase, the origin is increasingly connected to the environment and to historical and cultural factors linked to the different terroir. Each winery seeks its own market segment to represent its uniqueness and its regional key characteristics. The demand for wine shows a general reduction that mostly affects the price for standard wines (not quality or origin wines) while the segment for premium price and organic remains almost stable (status quo). The maintenance of a cohesive European Market but more open at the international trade is coherent with the maintenance of functioning EU market. However, the free trade and international competition (mostly characterised by an increase in the wine producing regions due to the regionalisation of consumption) increase also the supply of high-quality products (emerging markets may benefit for not-tariffs barriers) with the possibility for some products to obtain more favourable prices on these markets comparing to the national market. The dominant research is mainly performed by private companies which provide new technologies and equipment to reduce production costs or to improve the quality of the process. The value chain is dominated by retailers that – due to their economy of scale and to their ability to reduce transactions cost – try to increase the variety of wines into the supermarket and, meanwhile, try to reduce the number of wine supplier (few companies afford to represent the different producing regions).

– Scenario 3: Europeanization

The third scenario (Europeanization) is qualified by very strong European standards that set out the framework for both trade and production as well as for an increase in the demand. European Agricultural production is effectively protected and recognizable and ensures a quite high-quality level respecting higher sustainability and ethical standards. Thus, wine import into EU is very limited due to such high standards. This has determined an increase in production costs with an overall increase of the cost of food, and consequently of wine. At the same time, EU consumers show a high willingness to pay for healthy food as well as for food communicating a low impact on the environment and society. The increasing demand for origin, premium and organic wines, support the efforts of producers who have specialized their production patterns towards this market. The dominant research paradigm is characterised to increase competitiveness and food safety to reach extra-EU markets as well as to introduce technologies and practices to mitigate the effects of climate changes. The latter is for example oriented at introducing new varieties tolerant to drought and extreme weather. The value chain segmentation continues with the current trends but differ-

ent high prices for wine and has encouraged cooperation among producers, consolidating their position along the value chain.

– Scenario 4: Ecologisation

The fourth scenario (Ecologisation) is qualified by very strong European environmental standards that set out the framework for both trade and production but with a reduction of the demand that mostly affects the cheapest segments of production (standard and table wines) comparing with that of organic and high-quality wine, which remain almost stable. Furthermore, as Europe is going less dependent on external agricultural markets, there is no need for international trade. Meanwhile, a reduction in production is a consequence of export restriction due to low activity of trade with extra EU countries. European consumers – that are increasingly oriented towards the regionalization of consumption – show a very high willingness to pay for health food and for production communicating high environmental standards and origin. Moreover, wine demand is further contracted due to shifting in consumers' preferences towards health and safety consumptions (i.e. substitution of cheap wine with energy and improved nutritional drink). Therefore, the wine demand remains high only for premium prices wine. Relaxing of competition for prices as well as the new business model to meet the new demand for consumers have reduced the bargaining power of retailers and now there is no actor in a dominant position along the value chain. A balanced research system, between public and private research, ensure adequate provision of technology and practise to address Sustainable Development Goals (SDGs) as well as to improve knowledge exchange and mutual learning across wineries and along the supply chain.

c) Workshop Schedule

- 13.00 Registration
- 14.00 Workshop presentation, scopes and introducing scheduled activities at individual and collective level
- 14.15 Introducing first round of CSP individual analysis
- 14.30-15.00 Individual analysis (live survey)
- 15.00 Individual Scenario analysis (live survey)
- 15.45-16.00 Coffee break and cluster preparation
- 16.15 Introducing second round of CSP collective analysis
- 16.30-17.30 Collective/Group analysis (focus group discussion per cluster)
- 17.30-18.00 Discussion and conclusions

d) Animation techniques and instructions to participants

The workshop has been driven using a "metaplan-like" technique, that is:

- by training participants on the use of a smart application on their mobile phone to answer questions, taking comments, suggestions and other notes;
- by providing participants with post-it large enough (e.g. 15x20 cm) to be able to write two or three sentences with a pen;
- by leaving them enough time to reflect to the questions;
- by organizing collective discussion (for strategies and for solutions), in order (notably) to
  - identify solutions and strategies that are shared by most, and conversely, that are highly controversial
  - "cluster" the different strategies / solutions proposed by individual and in different groups.

e) Individual analysis (Live survey carried out during the workshop by launching the questions on the screen and having each participant answer via an app from their mobile phone).

1) Now we ask you to select one or more business goals for the next 10 years

Objectives	Max 3 obj.
Business development	
Reduction of production costs	
Maintenance	
Facilitate generational renewal (succession)	
Export growth	
Increase local markets	
Increase branding	
Renewing	
Quality	
Exit	
Other	Please specify

2) Which of the following changes in the conditions of demand, supply, territory and the environment do you think will affect your business choices in the next 10 years. Give an answer from 0 not influential 5 very influential.

Demand changes	0 nothing – 5 very
Greater attention to quality by markets and consumers (in addition to the origin, attention to premium wines, organic, from international blends, wines produced from native vines, light and easy to drink and mix wines, etc.)	
Change in the requested quantity (growth in regional consumption, opening of new markets or even vice-versa closing of markets such as the USA and decrease in regional consumption etc.)	
Changes in selling prices (request for lower prices and / or possibility to increase prices in emerging markets)	
Changes in consumption patterns (e.g. lower consumption of wine and search for drinks with a lower alcohol content)	
Increase in consumer knowledge and awareness (eg. Consumers who are more informed, more aware of what they drink, who do not choose only for the price but who carefully evaluate quality, brand and territory)	
Change in regulation on the main non-EU export markets (eg USA, Canada) and EU. (Change in tariffs, methods of access, trade agreements and accessibility to state monopolies)	

Supply changes	0 nothing – 5 very
Change in the offered quality (both in production and communication terms)	
Change in the quantity produced and in the production scale (growth and / or decrease in production, increase or decrease in the production scale)	
Greater attention to the origin and the territory (changes and / or simplification of the regulations, new rules related to the origin etc.)	
Changes in production costs (greater production efficiency and reduction of production costs or increase in input costs and consequently higher production costs)	
Search for greater production differentiation (increase in production of local grapes, transition to organic, biodynamic and other blends)	
Change in production technologies (increase in research into new varieties resistant to climate change, increase in technologies that can contribute to greater production efficiency)	

Territorial changes	0 nothing – 5 very
Changes in the access to factors of production – land, labor and capital (change in the regulation of planting rights, expansion of the vineyard area, increasing access to skilled workforce or contraction in its availability, greater access to capital for new investments, etc.)	
New entrepreneurs and generational change (continuation of the family business with family members and/or change with new qualified resources from the territory, or risk of exit from business due to lack of generational change)	
Change in agricultural policies (mainly CAP, RDP, and wine CMO measures) (e.g. opportunity of more incentives for restructuring, greater aid for the start-up of new productions and for young entrepreneurs, simplification of regulation, new support measures for promotion, etc.)	
Change in relations with institutions and other regional organizations (e.g. greater openness in decision-making processes, greater participation, and more direct and simplified communication with the various bodies that regulate the sector and/or development of new territorial bodies such as OPs, new types of consortia, etc.)	

Environmental changes	0 nothing – 5 very
Changes due to a greater or lesser presence of extreme weather events	
Changes in the management of water resources and soils due to an increase in drought periods	
Changes linked to an increase of invasive species and pests	
Changes in the management of soil fertility and natural resources	
Changes related to the management of the rural landscape	

3) Now we ask you to select from the following strategies those that you think could allow you to pursue your business objectives over the next 10 years. Which of the following could be your key strategy in the next ten years?

With regard to this part (strategies), after a first round of answer, we introduced the four scenarios and we replicated the questions for each scenario. We asked to the participants which of the following strategies could be implemented within the reference scenario for the next 10 years.

Strategies to increase competitiveness	Select relevants
Aiming at the company's production efficiency, reducing inputs and improving processes on both vineyard and cellar	
Increase production specialization thanks to greater research and increased management & control on grape varieties and cellar processes	
Focus on quality and origin (e.g. reduced yields but higher quality)	
Intensifying production by increasing yields per hectares	
Wineries diversification (developing new products and/or new types of business)	
Product diversification	
Aiming at technological development for greater control of production and production efficiency.	
Develop territorial partnerships	

Forming new productive organizations, associations or joining cooperatives or PDO/PGI Consortia	
Market orientation	Select relevants
Improving the ability to access to markets through export broker, or market intermediaries or by investing in the creation of in-house export competences	
Investing in the development of new markets	
Invest in the creation of corporate units and/or specific resources in the management of commercial relations on foreign markets through new commercial and/or distribution companies (internationalization of added value)	
Develop the lever of marketing and promotion in a cooperative perspective through consortia and other producer organizations and associations	
Formalize presence on the markets through greater use of contractual instruments (e.g. annual or multi-year distribution contracts, contracts with intermediaries, etc.)	
Reduce market risks though risk protection and management contracts and/or insurance contracts	
Status quo (survival)	Select relevants
Farm diversification	
Increasing non-agricultural activities	
Reduce business (part-time)	
Reduce the demand for external labour and improve the internal capacity to satisfy production needs	
Resizing	
Policy support	Select relevants
Increasing networking activities, partnership or the recourse to business associations (horizontal cooperation) in order to achieve business objectives	
Increasing lobbying capacities and ability to access to RDP, CMO resources	
Investing resource to acquire subsidies, tenders and other forms of support to achieve company objectives	
Investing in R&D	
Risk management	Select relevants
Insurance contracts to reduce production and market risks	
Flexibility	
Assets, corporate functions and underused structures liquidation to recover and maintain liquidity	
Investment in credit recovery and debt management	
Long-term contracts with large distributors	

f) Collective analysis

First, we divided participants in 8 different clusters according with the following specification:

Wineries size	Type of production	Export level	
		<50% turnover	>50% turnover
Small	Conventional	1	5
	Organic/Biodynamic	2	6
Large	Conventional	3	7
	Organic/Biodynamic	4	8

Each cluster was composed by 4/5 stakeholders and two facilitators. The goal was to create discussion groups with similar characteristics/background to facilitate the sharing of problems and the networking of potential strategies.

Then we asked in each group to:

a) To identify a new cluster objective and to evaluate whether this objective was realistic or not within each scenario (robustness of the scenario)
b) What individual and collective strategies would they have put in place to achieve the cluster objective in each scenario
   Here facilitators organized with poaster and post-it the collective discussion:
   - to select strategies that were shared by most, and conversely, that were highly controversial
   - To "cluster" the different strategies / solutions proposed in the different groups.
c) Finally, we asked participants in the different groups to reflect on potential policy needs to achieve the group's goal.

Finally – in a plenary session – one or two representatives of each group presented the most debated scenarios and their related strategies and solutions.

ANNEX 2
"WEB-BASED WORKSHOP" (MAY 15, 2020)

a) Objectives

The aim of the Web-based Workshop was threefold. Firstly, it was aimed at discussing the impact of the sudden changes driven by the pandemic on wine producers' strategies and performances. Secondly, it intended to provide with a space for stakeholders to make their own recommendations for the sector. Thirdly, stakeholders were expected to improve our understanding of the policy implications of the findings emerged from our

research activities before and during the crisis. To pursue these objectives, we did not foresee a rigid analytical structure, but the workshop was instead promoted as a co-reflection exercise with 20 international wine key actors (international winemakers, market consultants, agricultural consultants, wineries, representatives of regional institutions, academics and students) to engage stakeholders and elicit through an open-discussion the most significant CSP aspects that emerged from the pandemic. Thus, the workshop was intended to 'ground-truth' on the previous CSP findings and better clarifying the role of the different pandemic stressor(s) in driving adjustment processes and the dynamics that drove wineries from the 'baseline CSP' in the past to the new framework with respect to the current pandemic state and to the future sustainability and viability of the sector. Against this background the animation technique allowed participant to discuss carefully on the key topics introduced by pandemic, to stress different directions, including unpredicted events and issues.

The structure of the workshop included two rounds of 10 presentations of 10 minutes each with 5 minutes of open discussion and at the end an hour of round table discussion between participants. The workshop employed a moderator for the presentations and a round table facilitator who returned a final summary of the day. Then data collected allowed researcher to develop a backward reflection and a comparison with the initial CSP set, including short-term implications for different geographical contexts (Italy, France, Spain, Portugal, Australia, and US) analysed in the workshop.

b) Workshop Schedule

- 10.00 Workshop introduction, scopes and scheduled presentations
- 10.15 First round of Workshop presentations
- 12.30 lunch break
- 13.30 Second round of Workshop presentations
- 16.00 Coffee break
- 16.15 Round Table
- 17.00 Discussion and conclusions

c) Researcher backward reflection

With data collected in the second workshop we developed a comparative analysis to understand the context and evolution of the sector under the pandemic crisis. The aim of this exercise was to reflect on possible changes on the initial CSP set, as well as address the important contingencies introduced by the pandemic. The reflection was guided through a grid of key issues developed to consider and discuss all impacts of the pandemic on the key elements of the CSP framework (Table 1a).

Table 1b. Reflexive questions on strategies after pandemic.

Guiding question	What we want to understand on CSP
1. Where and how (channels) producers commercialise their products?	Markets and marketing
2. What are the main challenges with customers and demand introduced by the pandemic?	
3. What are the marketing strategies in place to secure export?	
4. What are the contextual change that influenced most their business model?	
5. What are the role of policies?	
6. How do they maintain/finance their activity, and what they require after the crisis?	Financing
7. Do they show a cooperative approach? How did this start? How is it going? Will they continue in the future?	Horizontal coordination
8. Do you collaborate with others in the value-chain? How did this evolve? Will you continue with this in the future?	Vertical cooperation
9. Do they feel that the current policy context can help to overcome the pandemic crisis and improve their business performance?	Policy and regulations
10. What about the environmental constrains and social challenges that they need to address?	
11. How do they deal with current policies and regulations? What are their main strategies?	
12. What about the sustainability of the sector, how would they define this impact?	Financial Sustainability

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Public R&D and European agriculture: impact on productivity and return on R&D expenditure

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Abstract. While higher effort in research is advocated for agriculture, there continues to be a lack of measurement of its impact in economic terms, at least in Europe. This paper seeks to assess the economic impact of public agricultural R&D investments in Europe. Different panel models are applied on 16 European countries, by employing productivity and investment data. Results show positive impacts with returns on public R&D investments on agricultural productivity of between 6.5% and 15.2%, varying according to model specifications and computation techniques. These values confirm that research expenditure in agriculture is well justified in economic terms. However, the results are highly dependent on the analytical approach and limited by the paucity of expenditure data. Further research is recommended to take into account the role of other important determinants of impact, such as climate, spill overs and the Common Agricultural Policy (CAP). However, a proper consideration of these variables will first require a major improvement of data availability.

Keywords: public R&D investments, agricultural productivity, rate of return, Europe.
JEL Codes: O33, O47, Q16.

1. INTRODUCTION

Public agricultural research investments in developed countries has shown contrasting trends in recent decades, including a reduction in some documented cases (Hurley et al., 2016; Pardey et al., 2016; Rao et al., 2016; Pardey et al., 2018). While the reasons for current trends in public R&D investment in developed countries can be debated, representing a paradox (Alston, 2018), institutional and political reforms are in place in middle-income countries aimed at supporting both research and agricultural productivity (Wang et al., 2012; Fuglie, 2016). At the same time, private investments in research and development (R&D) in the agri-food sector notably increased, especially in upper middle-income countries (Pardey et al., 2018).

It is well known, since the first study by Griliches (1958), that public investments in agricultural research are highly profitable in the long run (Alston et al., 2000; Piesse et al. 2010; Hurley et al., 2014) and are acknowledged to be a fundamental driver for the improvement of agricultural pro-

ductivity (Ball et al., 2001; Ball et al., 2010). At the same time, the literature admits the limitations and, in many cases, the lack of reliability of the agricultural productivity measurements as well as their difficulty in representing the actual evolution of the agricultural sector and the profitability thereof (Alston et al., 2010; Wang et al., 2012; Hurley et al., 2014; Rao et al., 2016). Better measurements and more reliable estimates of agricultural productivity and rates of returns (RoR) would be helpful in guiding public investment choices. Indeed, the improvement of methodologies for quantifying the impact on agricultural productivity, with the aim of precisely estimating the RoR of research investments in agriculture, is an issue that has been challenging economists for a long time, especially in developed countries. Indeed, the ongoing literature discussion (Davis, 1981; Alston et al., 2000; Hurley et al., 2014; Oehmke, 2016; Hurley et al., 2016b) is still focusing on adjusting the RoR estimates because they are considered, for several technical reasons, (upward) biased and hence not fully reliable. However, in Europe, recent evidence of returns on public investments in agricultural R&D are scarce because of limited data availability.

Besides the difficulty of establishing a connection between R&D expenditure and productivity, the literature observes a change in focus of European agricultural policies (and public R&D effort) from purely productivity-focused objectives towards guaranteeing the environmental sustainability of agricultural production, the health and safety aspects of food and feed production, along with other aspects related to the degree of protection and promotion of public goods[1] (Gardner and Lesser, 2003). In contrast, the more production-oriented investments in agricultural R&D are 'left' to the interest of private (business) investors (Pardey et al., 2018). Further, scientific evidence from the InSTePP database (Pardey et al., 2018) reveals that part of the R&D investments in agriculture are devoted to "maintenance" of productivity levels obtained in previous years.

The objectives of this paper are to assess the contribution of public investments in agricultural research to agricultural productivity in Europe, through a quantitative analysis, and to measure the economic impact of research expenditure in terms of RoR.

Consistently with this branch of the literature, the focus of the paper is on public expenditure related to agriculture (see section 3 three for more details) and not on research policy (i.e. how money is spent and what incentive instruments are used)[2]. The main contribution of the paper is on the empirical ground as it contributes to fill a gap in the recent literature, which does not include recent analyses of R&D impacts on European agriculture. In fact, the only 'recent' study addressing the issue is that of Schimmelpfennig et al. (1999), analysing the 20-year period from 1973-1993. In addition, this paper also provides a methodological contribution by tailoring suited analytical methodologies to the limited available data, especially the series on public R&D expenditure in Europe.

This paper proceeds with a section on the review of the relevant literature (section 2), followed by the selection of the available data (section 3) and the presentation of the chosen methodology (section 4). Two subsequent sections provide the illustration of the results (section 5) and related discussion (section 6). The paper ends with a concluding section (section 7).

2. LITERATURE REVIEW

The connection between spending on research and development (R&D) and agricultural productivity has diffused evidence in the literature (Griliches, 1958; Parente, 2001; Hall et al, 2010). The nature of such a connection, firstly explored by Shultz in 1953, is to be referred to what would have been formalized as the *Solow model* after Solow (1957): technological change and inputs are responsible for the long-run variations in rates of growth of output, with technology being the unobserved exogenous factor of the aggregated production function and estimated *ex-post* as *residual*. Applying the Solow model, most studies (Alston et al., 2000; Ball et al., 2001; Fuglie, 2016) measure agricultural productivity by the means of Total or Multi Factor Productivity (TFP or MFP), namely the Solow residual. The computational methods and estimation techniques of the TFP have been largely improved over time (e.g. the aggregation and index numbers and the dual approach, *inter alia*) (Hall et al, 2010). Yet they remain in the framework of the Solow model, therefore treating technology advances – and their causes – as exogenous elements of the models. Such a framework, in fact, completely ignores the decision process of agents and institutions for generating and adopting new technologies and, hence, treats change in technology as a costless factor.

[1] For a wider and more comprehensive description of recent perspective on these aspects, see the Deliverable 4.2 of IMPRESA project, downloadable at http://www.impresa-project.eu/home.html

[2] For these and more aspects related to institutional aspects and to the relationship between European R&D policies, CAP and more policies the reader might refer to the other documents and publications of the IMPRESA projects.

The further objective of this type of studies is to estimate the rate of return from public investments in agricultural research. Based on the same neoclassical framework, research expenditure is treated as a capital input affecting the agricultural supply function (causing shifts in the supply function) and, therefore, the TFP. The contribution, in terms of effects, of public research expenditure on the evolution (increase) of agricultural productivity is then used as the basis for the computation of the RoR on investment, under a cost-benefit analysis framework.

Alternative theoretical and methodological approaches are applied, instead, for estimating the RoR of private R&D investments (Hall et al., 2010). The main difference rests in the specification of the maximizing behaviour of the firm, which includes elements pertaining to the private sector, such as market power, strategic behaviour, variable return to scale (long-run RoR) and own spill over stocks. Another important distinctive factor is the joint determination of R&D investment and expected RoR, which, in fact, causes the emergence of measurement issues of RoR on private R&D investments as well as manifold interpretations of the estimates, especially of the RoR, due to the condition of endogeneity of the R&D variable.

Common issues to tackle in the evaluation of public and private RoR on R&D investment are the estimation of the rate of return and its interpretation. In fact, both topics are still feeding the academic debate and, despite efforts by Alston et al. (2011) and Hurley et al. (2014) in proposing a more cautious approach for estimating RoR (taking into account reinvestment factors) and for providing results more suitable for plausible interpretations, the issue of correctly estimating RoR remains unresolved. Such an issue appears clearer in the meta-analysis proposed by Alston et al. (2000) and, more recently, in the worldwide collection of RoR studies by InSTePP Returns to Research (RtR) Database (Hurley et al., 2016a). What emerges from these reviews is a likely overestimation of the marginal effects of R&D investments on productivity, which, in turn, affects RoR estimates (Hurley et al., 2014; Oehmke, 2016; Hurley et al., 2016b). In order to try to address this issue, it would be useful to minutely isolate the effects of R&D investments on agricultural productivity by considering potential factors, other than R&D investments, affecting the returns on R&D in agriculture, such as: the intra- and extra-sectorial spill over, the role of the structural transformation in the agricultural sector (Timmer, 1988), the influence of policies on agricultural production and productivity (Restuccia et al., 2008) and the effect of the growing competitive pressure on the European agricultural sector (Galdon-Sanchez, 2002; Schmitz, 2005; Duarte et al., 2010).

3. DATA AVAILABILITY AND SELECTION

To estimate the return to investments in agricultural research, two groups of data are needed: expenditures on agricultural R&D and measures of agricultural productivity. At the European level, data on R&D expenditure are collected according to two main categories: Gross domestic Expenditures on R&D (GERD) and Government Budget Appropriations or Outlays on R&D[3] (GBAORD). GERD data group the actual intramural expenditures on R&D, while GBAORD data refer to all appropriations by central governments allocated to R&D in central government or federal budgets. Unless otherwise stated, GBAORD data include both current and capital expenditure and do not only cover government-financed R&D performed in government establishments, but also government-financed R&D performed in the business enterprise, private non-profit and higher education sectors, as well as abroad[4].

Agricultural GERD time series are difficult to use in econometric analyses, as data are missing for several years, especially before 1996, and several countries do not have any records to speak of. The use of the alternative source, GBAORD data, as an indicator (or measure) of agricultural R&D investment may hold only under the condition of considering solely public R&D investments, provided that GBAORD can represent a reliable proxy of GERD public R&D expenditures. A comparative analysis of public GERD (for all fields of science), revealed that the difference (or divergence), in average terms per country, at the European level is 3% with respect to GBAORD[5]. For this reason, GBAORD data have been considered as a suitable proxy of actual expenditure for the aims of this paper.

GBAORD data are covering all public budget spending related to R&D and are linked to policy issues by means of a classification by "objectives" or "goals". Programmes are allocated between socio-economic objectives on the basis of intentions at the time the funds are committed and not the actual content of the projects concerned. These breakdowns reflect policies at a given

[3] Since 2019, GBAORD are renamed GBARD: Government Budget Allocations for R&D

[4] This and further methodological information can be found in the revised version of the Frascati Manual, OECD 2002.

[5] For a wider and more comprehensive description of GERD and GBAORD data, see the Deliverable 4.1 of IMPRESA project, downloadable at: http://www.impresa-project.eu/home.html

moment in time. GBAORD data are organized according to NABS.

GBAORD data from 1980 to 2007 on agricultural production and technology are collected according to NABS 92 chapters and sub-chapters:

- General research:
  - Fishing and fish-farming;
  - Crops;
  - Forestry and timber production;
- Animal product:
  - Veterinary medicine;
- Food technology;
- Other research on agricultural production and technology.

GBAORD data since 2008 on agriculture are collected according to the NABS 07 unique chapter Agriculture, which *de facto* aggregate the sub-chapters listed under NABS 92.

For Agriculture, GBAORD data collected according to NABS 92 are available for chapters and sub-chapters, while GBAORD data collected according to NABS 07 are available for the unique chapter[6].

Agricultural productivity series are available from USDA in terms of TFP, computed upon agricultural input and production data, available from FAOSTAT, over the period 1961-2010 for all countries worldwide. Another series of agricultural TFP is available from the KLEMS project (2016), but these differ from the ones computed by the USDA because they take into consideration improvement in qualitative aspects of both agricultural products and inputs. Even if they are apparently an attractive data source for econometric analysis, in light of inclusive of qualitative attributes, the limited series availability for several European countries and the indexation 1995=100 do not allow for KLEMS data to be suitable for quantitative analysis[7]. Based on this, TFP series from USDA have been preferred as productivity measures to be employed in the present study as the data are complete and available for all European countries and the reference value 100 is set in 1961 (out of the observed period[8]).

GBAORD data on agricultural R&D expenditures have been selected from the OECD database because they are measured in USD and, for this reason, comparable to the production measures provided by FAOSTAT and, in turn, to TFP measure provided by USDA.

The following 16 countries provide for the most complete series of agricultural GBAORD and, hence, have been selected for the aims of the present study: Austria (AT), Belgium (BE), Denmark (DK), Finland (FI), France (FR), Germany (DE), Greece (EL), Ireland (IE), Italy (IT), The Netherlands (NL), Norway (NO), Portugal (PT), Spain (ES), Sweden (SE), Switzerland (CH), and the United Kingdom (UK). For statistical and analytical purposes, the selected countries guarantee a rather good representativeness of Europe, in particular because of the presence in the sample of Nordic, Continental and Mediterranean countries. Complete series of agricultural GBAORD are available starting from 1981 to 2013. However, in order to align them with USDA productivity series, the time series are intentionally selected up to 2010.

Table 1 shows that only six out of sixteen countries – FR, DE, IT, NL, ES and UK – record average agricultural GBAORD values largely over 100 MUSD in the period considered. By looking at physical and economical dimensions (from FAOSTAT), it is possible to note that public agricultural investments, at country level, are to a large extent proportional to both agricultural fixed capital (mainly represented by agricultural land) and the value of agricultural production.

Another factor emerging from the selected sample is the variability per country of the investment in agricultural R&D over time (yearly trend – Aver. % Δ in table 1). The most extreme examples from the selected countries are BE, EL and UK, which have steadily disinvested in agricultural R&D over the last three decades, and AT, FI and NO, which, on the contrary, recorded constant increases. The remaining countries, instead, show intermediate averages generated by alternating periods of increases and decreases in agricultural R&D investments.

An exhaustive presentation of the FAOSTAT production and input data is available on the USDA website (2016) and in Fuglie (2016). Given the objectives of this study, the use of FAOSTAT agricultural data are preferred to Eurostat data since the latter does not provide a complete series over time. Another reason has to do with comparability in constant 2005 USD with R&D investment measures, at least for gross agricultural production (GAP)[9]. A synthetic analysis[10] reveals that FR, DE,

[6] For further details, please refer to RAMON – *Reference And Management Of Nomenclatures* provided by EUROSTAT.

[7] Despite this, a comparability test has been performed on both datasets to check potential longitudinal differences. To make both series comparable, the data have been transformed in growth terms with respect to the fix year 1980. The equality (t-test) test reveals that the time-series are different in terms of growth trends.

[8] For more details about the computational methodology, visit the USDA website:https://www.ers.usda.gov/data-products/international-agricultural-productivity/documentation-and-methods/ .

[9] TFP measures are computed from GAP, hence allowing for the comparability between TFP and R&D investments.

[10] A detailed descriptive analysis is available at: http://www.impresa-project.eu/home.html, Deliverable 4.1 of IMPRESA project.

Table 1. GBAORD for agriculture – Million 2005 Dollars – Constant prices and PPPs (time averages).

	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland
Mean	41	59	73	80	526	470	51	57
St. Dev.	6.4	20.6	22.7	13.6	170.6	128.1	12.7	27.4
Aver. % Δ[1]	0.80%	-3.87%	1.42%	1.68%	-2.94%	1.82%	-1.82%	4.48%
	Italy	Netherlands	Norway	Portugal	Spain	Sweden	Switzerland	United Kingdom
Mean	277	176	112	107	311	46	47	519
St. Dev.	89.7	37.9	22.1	39.0	240.5	11.9	13.6	105.3
Aver. % Δ	1.54%	0.00%	1.98%	3.13%	7.13%	0.00%	0.00%	-2.07%

Source: own elaboration on OECD data.
[1] Per each country, the trend has been computed linearly through OLS (the estimated coefficient of time) and then averaged by the mean of the series.

IT, NL, ES and UK are the European countries with the highest shares of GAP, having each an average (sample) value over 5%. Cumulatively, these countries cover about 80% of the GAP value of the European agricultural sector and their average GAP trends have been stable over the period 1980-2010. The group formed by the remaining countries, AT, BE, DK, EL, IE, NO, PT, CH, SE and FI, records a global increase in GAP (mostly up to 2000 then flattening or decreasing thereafter). Despite the differences observed at the country level, a weak increase in GAP trends in the 1980-2000 period, followed by a marginally decreasing growth tendency, seems to characterise the general pattern of the agricultural sector at the European level.

The possible determinants of this observed pattern are to be identified in factors underlying production processes that contributed to improve the productivity of inputs (technology, innovations, knowledge…), in other elements characterising the multifunctional nature of the European agricultural sectors (environmental protection, food safety, diversification, climate change) as well as in measures providing constraints (cross-compliance, agro-environmental schemes) or reducing incentives (decoupled payments) to agriculture productivity provided by the Common Agricultural Policy (CAP). The data on R&D expenditure are available at a European level, but considering country level investment in agricultural R&D. Data are not referred to a European Union context, but rather at the country level expenditures. This includes EU funds and the CAP component related to R&D, but it is not explicitly disaggregated. Therefore, we omitted explicit references to CAP or to other related EU policies.

Unlike the GAP and production inputs, TFP is not an observed measure but rather a complex index expressing the relative change, over time, of the technical contribution of production inputs to output. Indeed, the evolution of the TFP index is, as suggested by Fuglie (2016), highly sensitive to R&D investments in terms of both improvement of the production frontier, through *technical change* (by increasing output levels) and rise in input productivity, through *technical and allocative efficiency* (by decreasing input levels). This implies that the use of the TFP index allows for a more precise identification, with respect to the use of GAP and inputs, of the contribution of R&D investment on productivity.

Table 2 shows the evolution of TFP for the sample countries over the considered period 1981-2010. The first information to highlight is that the average level of TFP index for some countries, such as IE, NO, PT and CH, is close to the reference level. The meaning of such datum is that productivity in those countries lagged behind (20 years from 1961 to 1981) with respect to the others.

On the other side, there are some countries, such as BE, DK, DE, IT, NL and ES, for which the average TFP index is greater than 200. Such variability across countries in TFP index is a favorable element for the reliability of an inferential procedure aimed at estimating the impact of R&D investments over years at country levels, i.e. the exercise we are carrying out in this paper. By looking at the yearly trends, in terms of average percent change, the sample shows a notable variability across countries, from about 1% for UK to 4% for DK. Indeed, a deeper exploration of the yearly evolution at country level, not shown in Table 2, shows that most countries record a flat trend until 1990 (1987 for IT, NO, PT and ES) and a steady (but variable across countries) increase thereafter. Only NL and SE show constant positive tendencies along the entire period[11].

[11] For a detailed description of the TFP series see the Deliverable 4.1 of IMPRESA project, downloadable at: http://www.impresa-project.eu/home.html

Table 2. Total factor productivity (TFP) (reference level: 1961=100).

	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland
1981	130	139	121	122	119	134	147	109
2010	263	226	330	190	222	292	215	160
Mean	194	201	208	155	167	210	188	133
St. Dev.	48.65	38.75	72.44	28.05	37.89	54.19	32.10	18.64
Aver. % Δ	2.73%	1.98%	3.88%	1.51%	2.51%	2.86%	1.88%	2.65%
	Italy	Netherlands	Norway	Portugal	Spain	Sweden	Switzerland	United Kingdom
1981	163	169	105	89	193	115	116	136
2010	358	365	164	209	386	196	218	172
Mean	227	239	131	137	270	159	139	153
St. Dev.	58.71	53.35	17.95	34.54	67.92	26.57	27.06	10.86
Aver. % Δ	2.82%	2.45%	1.41%	2.80%	2.73%	1.87%	2.03%	0.78%

Source: own elaboration on USDA data 1981-2010; the first line includes values for 1981 as a term of reference.

The flatness of TFP until 1990 might prove to be a factor consistent with the supposed role of R&D investments in inducing productivity growth over time. In fact, given that the trends of the inputs do not show flat trends, but rather decreasing ones along the entire period, it is plausible to hypothesize the attribution of the initial stability and the subsequent growth of TFP to a likely progressive growth in technical and allocation efficiency originating from research. This preliminary assessment suggests that the selected data could be considered suitable for testing the hypothesis of a relationship between R&D expenditures in agriculture and agricultural productivity. Based on available time series, in this paper we estimate the direct impact of public expenditure on R&D on TFP and, in turn, the relative RoR, by employing the most appropriate methodology, suitably tailored to the available series of data.

4. METHODOLOGY

Despite many years of academic analysis, the study of the impacts of agricultural R&D on the economy has not converged in a well-established and agreed upon methodology. Two main theoretical streamlines of economic growth support the study of economic impact of R&D, the exogenous and endogenous growth models, which in turn give rise to different methodological approaches. The differences, as well as the *pros* and *cons*, between these main approaches for the study of the economic impact of R&D are well exposed by Parente (2001), who considers the exogenous growth model the best analytical framework for the assessment of economic growth because it best describes the convergence process of countries' economies. Within the framework of the exogenous growth model for assessing the RoR, expenditures in R&D are employed as a proxy for knowledge accumulation and, therefore, treated as an exogenous capital input in the estimation process. This assumption implies that the effect of the R&D investment is supposed to persist beyond the first year, therefore affecting more than one production cycle[12]. This condition implies the use of time series analysis techniques because the focus is on assessing the long-run growth and returns. However, being aware of the limitations of the available data and the consequent impossibility of applying the best available methodology, a wide review of the recent literature, including, *inter alia,* Schimmelpfennig et al. (1999), Fan (2000), Oehmke (2004), Ali (2005), Alene et al. (2009), Alene (2010), Suphannachart (2011), Andersen (2013), Hurley et al. (2014) and Jin et al. (2016), has been carried out to identify the analytical approach that could best exploit the informational power of the available data.

These studies provide a variety of approaches and model specifications for the estimation of the impacts of agricultural research on productivity. The methodologies adopted are diverse across the reviewed works and have been likely chosen to best exploit the available data of each study. In fact, agricultural productivity is measured in GAP, Value Added, TFP and MFP, while research is measured in knowledge stock, distributed or single lags of R&D expenditure. In fact, the way research is assumed to impact productivity over time is also modelled in several ways, either by imposing a certain number of lags, based on specific assumptions

[12] In this case, the production cycle coincides with one year.

regarding the nature of the research system mainly present in a country (basic, experimental, adaptive, extension, etc…) (Alene, 2010), or by inferring the length through information criteria of regression models, such as Adjusted R^2, AKAIKE, Likelihood ratio and other criteria (Fan et al., 2000; Alene et al., 2009). The presence of lags inevitably yields estimation issues (biases) due to multicollinearity, implying the imposition of a limit in the length of the time lag. Furthermore, research lags are not modelled according to a linear impact path, but rather designed in specific shapes accommodating the largely shared hypothesis that the impacts of R&D grow in the early years right after the implementation of the research, reach a peak and then decrease. Such non-linear impact paths are modelled in different ways in the literature, in particular as PDL (polynomial distributed lags), Gamma distribution function, triangular or trapezoidal (Sumelius, 1987; Thirtle and Bottomley, 1988; Thirtle and Bottomley, 1989; Thirtle et al., 1995; Schimmelpfennig et al., 2000; Alene, 2010).

The most accredited literature is not unanimous on the required lag length and differences depend on the underlying assumptions. In fact, in order to assess the total effects of R&D expenditures from the beginning of a research project to the complete obsolescence of the related technology, Alston et al. (2000) suggest a period of at least 50 years. Pardey and Craig (1989), instead, indicate the necessity of a lag length of at least 30 years to be able to capture the long-run impact of R&D on agricultural output. It is useful to stress, however, that such a condition is mainly found in studies in which the United States is the subject of the estimation and for which the assumption of the research activities, composed mainly of basic (relative to applied) research, is coherent with the hypothesis of long-term impacts on productivity. In Europe, however, previous studies adopted, on average, lag lengths of less than 30 years. Although the methodological approach applied in the European studies is in line with the one applied in the US studies, the best performance of the estimation models applied on Europe data is achieved with an average lag length of between 9 and 12 years and by imposing a polynomial distributed lag (PDL or Almond) structure (inverted "U"), through which a dynamic evolution (rise-peak-fall) of the effects can be accounted for (Sumelius, 1987; Thirtle and Bottomley, 1988; Thirtle and Bottomley, 1989; Rutten, 1992; Shimmelpfennig et al. (1994); Thirtle et al., 1995). Indeed, as highlighted by Shimmelpfennig et al. (1994), Piesse et al. (2010) and Pardey et al. (2018), the likely prevalence in Europe of adaptive research activities (with respect to basic research) accommodates the assumption of reduced R&D lagged effects (with respect to the US) and, according to Piesse et al. (2010), the use of 30 year series ought to be sufficient to capture lagged effects of R&D on productivity and acceptable from a methodological perspective. It follows that the models in the literature with the characteristics we are looking for are the ones proposed by Alene et al. (2009) and Alene (2010). Such models proved to be able to manage relatively short time series and to provide for robust results by employing structured lagged variables for R&D expenditure.

Given the objectives of this paper, we intend to apply a panel analysis, opportunely specified such as to accommodate at best the available data. The model specification has the objective of estimating the effect of the R&D expenditure on TFP, through the most efficient estimator of the panel models[13].

We used a TFP (Total Factor Productivity) index as dependent variable, and R&D investments GBAORD (constant 2005 USD) (OECD) and lags, in terms of *PDL* as independent variables.

To overcome the issue of multicollinearity of R&D lags, the following polynomial distributed lag (PDL) specification of second order has been applied to R&D lag variables (GBAORD):

$$PDL=\sum^{J}_{j=0}\alpha_j(R\&D_{t-j}) \quad (1)$$

$$\alpha_j=\beta_0+\beta_1 j+\beta_2 j^2 \quad (2)$$

with j=0,1,…,J, where J represents the maximum lag or, in other terms, the lags' length;
by substituting (2) into (1), we obtain the following formulations of the *PDL* variable:

$$PDL=\sum^{J}_{j=0}(\beta_0+\beta_1 j+\beta_2 j^2)(R\&D_{t-j}) \quad (3)$$

$$PDL=\beta_0\sum^{J}_{j=0}(R\&D_{t-j})+\beta_1\sum^{J}_{j=0}(R\&D_{t-j})j+\beta_2\sum^{J}_{j=0}j^2(R\&D_{t-j}) \quad (4)$$

To avoid crossed effects between R&D and productivity (negative α_j coefficients)[14], an end-point restriction is applied such that expenditures in years t+1 have zero effects on productivity in year t:

$$\alpha_{-1}=\alpha_{j+1}=0 \quad (5).$$

By expanding (5), the following specifications can be obtained:

[13] To evaluate whether to employ the fix- or random- effect model.
[14] By crossed effect between R&D and productivity is meant the potential effect that TFP at time t might have on R&D at time $t+1$, that is the negative coefficients.

$$\alpha_{-1}=0\Rightarrow\beta_0+\beta_1(-1)+\beta_2(-1)^2=\beta_0-\beta_1+\beta_2=0\Rightarrow\beta_0=\beta_1-\beta_2 \quad (6)$$

$$\alpha_{J-1}=0\Rightarrow\beta_0+\beta_1(J+1)+\beta_2(J+1)^2=\beta_0+\beta_1J+\beta_1+\beta_2J^2+ 2\beta_2J+\beta_2J=0. \quad (7)$$

By substituting (6) in (7) and then (8) back in (6), the following final specifications are obtained:

$$\beta_1-\beta_2+\beta_1J+\beta_1+\beta_2J_2+2\beta_2J+\beta_2=0\Rightarrow\beta_1(2+J)+\beta_2(2+J)J=0 \Rightarrow\beta_1=-\beta_2\mathrm{J} \quad (8)$$

$$\beta_0=\beta_1-\beta_2\Rightarrow\beta_0=-\beta_2J-\beta_2\Rightarrow\beta_0=-\beta_2(1+J). \quad (9)$$

The restriction implies the estimation of only β_2 and obtaining the other coefficient from the following equations (8) and (9). Once the β_2 coefficient has been obtained, the effects $\alpha_j\forall j$ and the total effects $\sum^J_{j=0}\alpha_j$ can be estimated.

The lag length J has been decided through the max $AdjR^2$ criterion, which makes it possible to choose that lag that maximizes the adjusted R^2 of the free-form lag structure of the estimation equations (Fan et al., 2000; Greene, 2003; Alene, et al. 2009).

Two different specifications of the panel model have been applied and controlled for heteroscedasticity:

1. TFP *level*: $TFP_{it}=\gamma_0+\gamma_0PDL_{it}+e_{it}$, *PDL* computed on GBAORD;
2. TFP *log*: $\ln TFP_{it}=\gamma_0+\gamma_0PDL_{it}+e_{it}$, *PDL* computed on *ln*(GBAORD)

where *i* indicates the countries and *t* the period between 1981-2010. Given the proposed methodology, it is expected that the sign of the *R&D* lags (calculated back from *PDL*) will be positive[15]. Random- (REff) and fix-effect (FEff) models produce estimates according to the computational formula of the random-effect and within estimator, respectively. This implies a rigid constraint on the interpretation of the results, which must be attributed to, or referred to, the panel and not to the individual countries.

Data have been tested for the presence of unit root through several tests, both as a single series and as a panel, and the results indicate that not all series and panels are stationary. Given that this result is not sufficient for co-integrating the data, a further co-integration test, namely the Pedroni (2004) test, has been applied. The results of the Pedroni test indicate that the couple of series (TFP-GBAORD) share the same stochastic trend and that such data become stationary if a linear combination of the relative variables is applied[16]. Based on this, we opted for the use of standard OLS econometric procedures, in the version of the panel model, in order to obtain super-consistent parameter estimates (Andersen et al., 2013).

Within the framework of cost-benefit analysis, an effective methodology for the evaluation of the economic impact is the computation of the rate of return of R&D investments. In particular, by referring to several studies, especially to Griliches (1964) and Davis (1981), in this paper the computation of the RoR has been carried out according to the method of the marginal internal rate of return (MIRR).

The MIRR for both TFP specifications has been computed according to the criteria adopted by Alene (2010): $\sum^J_{j=0}\frac{VMP_{t-j}}{(1+MIRR)^j}=1$, with J="18" and t={"1981-2010"}, where VMP stands for *value marginal product* of R&D. Given that the RoRs have been computed upon estimates from panel models, they are unique for all the countries. Further, different average measures are applied, namely arithmetic vs geometric, in order to control for the potential effects of the deflation of the *value* variables, namely RE, on the VMP and RoR (Davis, 1981). In fact, important differences emerge from the comparison of the RoRs computed through the mentioned techniques. However, the application of geometric averages is not possible for the variables in level form because the relative computation formula of the VMP does not involve the average of R&D[17] (but also because, by definition, the geometric average of a variable is the equivalent of the arithmetic average of the logarithmic form of the variable). Therefore, the sensitiveness of the RoR computation with respect to the geometric mean is performed only on the TFP *log* specifications.

5. RESULTS

By applying the max $AdjR^2$ criterion, 18 lags have been found for TFP specifications, implying that the variable $PDL=\sum^J_{j=0}j^2(R\&D_{t-j})$ is computed with j=0,1,…,18.

The Hausman test applied on the TFP level specifications reports an estimated χ^2=9.59 and a $\rho<0.05$, revealing that the random-effect model results are more appropriate. For this reason, a further model including an autoregressive process of order 1 in the error term (AR(1)) is employed to consider likely effects of omitted

[15] The coefficient of the variable *PDL*, namely , given the imposed shape of an inverted parabola, is expected to be negative. The corresponding lag coefficients of R&D, instead, namely , are expected to be positive.

[16] More details about the unit-root tests are available from the authors upon request.

[17] The computation of *VMP* varies according to the TFP specification used in the models: the *log* form implies the use of average values of TFP and RE, while the linear form does not.

variables unlinked to single countries (coherent with random-effect model specification). On the other hand, the Hausman test applied to TFP *log* specification reports an estimated χ^2=0.02 and a ρ<0.89, suggesting that fix-effect model results more appropriate. However, we decided to run a REff model with AR(1) disturbances to account for missing variable bias, given that no efficiency as well as consistency would be lost. The lags imposed on the models, although computed empirically, have been double-checked by referring to the work by Piesse at al. (2010) who propose the existence of a diffusion path from the US to less developed Southern countries, passing by Northern and Southern Europe, backing the hypothesis that agricultural research in Europe is mostly adaptive rather than basic. Given this path, the lags from research to productivity in Europe may be expected to be shorter than the suggested 50 years. The empirical determination of the lags seems to confirm this hypothesis.

The variables in the TFP model specifications have been employed in the form of levels and logarithm. The results, displayed in Table 3, show the expected positive sign of the R&D estimates and high statistical significance.

Across the considered 18-year lag period, the variables on agricultural research (R&D) indicate positive and significant effects, shown in Figure 1, summing up to a total effect of 0,24 and 0,17, for the REff and REff with AR(1) specifications in level forms, and to a total elasticity of 0,10 and 0,09 for FEff and REff with AR(1) specifications in logarithmic form, respectively.[18]

By comparing the results of the different specifications of the models on TFP, interesting estimation aspects are revealed. In particular, the inclusion of the AR(1) component in the error term does not improve the regression accuracy (both R^2-within and R^2-between) as well as the estimation of the R&D effects, which, rather, turns out to be lower. The reason for this difference in the estimates (or lack of difference in R^2) might be related to the condition that both regressions include only one explanatory variable, namely R&D (in terms of *PDL*), inducing a lower impact when the AR(1) error component is considered. In this case, the relative importance of differences across countries *versus* time-related variability is null. Further, other aspects emerge from the regression performed through the FEff estimator in that it excludes the *between variation* from the estimation process. The results, shown under the column titled *Log form* in Table 3, indicate a lower performance of R&D (in terms of *PDL*) because the country-level effects are flattened out. However, the models run under the FEff and REff (w/o AR(1)) estimator return exactly the same results, while the inclusion of the AR(1) component lowers the elasticity estimates but does not affect the goodness-of-fit. The observed sensitiveness of the effect of R&D on productivity supports the need to include more variables that potentially might affect agricultural productivity in the long-run to better isolate the impact of R&D. In particular, we refer to other elements, especially country-specific factors, such as climatic elements, weather anomalies, private investment in research, spill overs and agricultural policy implementation. Although some of these have been tested in the models (such as climate and CAP) the obtained results were not improving. In fact, both variables were not statistically significant.[19]

Table 3. Results from TFP specifications.

TFP	Level form		Log form	
	REff	REff w/ AR(1)	FEff	REff w/ AR(1)
Constant	152.6***	169.5***	4.838***	4.908***
$R\&D_t$	0.003***	0.002***	0.002***	0.001***
$R\&D_{t-1}$	0.007***	0.005***	0.003***	0.002***
$R\&D_{t-2}$	0.009***	0.007***	0.004***	0.004***
$R\&D_{t-3}$	0.012***	0.008***	0.005***	0.004***
$R\&D_{t-4}$	0.014***	0.010***	0.006***	0.005***
$R\&D_{t-5}$	0.015***	0.011***	0.007***	0.006***
$R\&D_{t-6}$	0.017***	0.012***	0.007***	0.006***
$R\&D_{t-7}$	0.017***	0.012***	0.007***	0.007***
$R\&D_{t-8}$	0.018***	0.013***	0.008***	0.007***
$R\&D_{t-9}$	0.018***	0.013***	0.008***	0.007***
$R\&D_{t-10}$	0.018***	0.013***	0.007***	0.007***
$R\&D_{t-11}$	0.017***	0.012***	0.007***	0.007***
$R\&D_{t-12}$	0.017***	0.012***	0.007***	0.006***
$R\&D_{t-13}$	0.015***	0.011***	0.007***	0.006***
$R\&D_{t-14}$	0.014***	0.010***	0.006***	0.005***
$R\&D_{t-15}$	0.012***	0.008***	0.005***	0.004***
$R\&D_{t-16}$	0.009***	0.007***	0.004***	0.004***
$R\&D_{t-17}$	0.007***	0.005***	0.003***	0.002***
$R\&D_{t-18}$	0.003***	0.002***	0.002***	0.001***
$R\&D_{Total}$	0.24***	0.17***	0.10***	0.09***
R^2 within	0,3078	0,3078	0,6866	0,6866
R^2 between	0,0101	0,0101	0,1172	0,1172

Note: *** represent statistical significance at the 1% level. Standard error for lagged R&D coefficients has been computed via Delta method.

[18] Each coefficient of the variable $R\&D_{t-j}$, i.e. current and lagged effects, has been computed from the original estimates of the *PDL* variables β_2=-0.000182 (z-value= -13.64) and β_2=-0.000129 (z-value = -5.24) for both RE model specifications in levels, respectively, and β_2=-0.000077 (t-value = -9.00) for FE model specification in logarithm.

[19] For climate, we used two climatic indexes, growing and cooling degree days indexes, estimated by the Joint Research Center (JRC) of the European Commission within the framework of AGRI4CAST Tool-

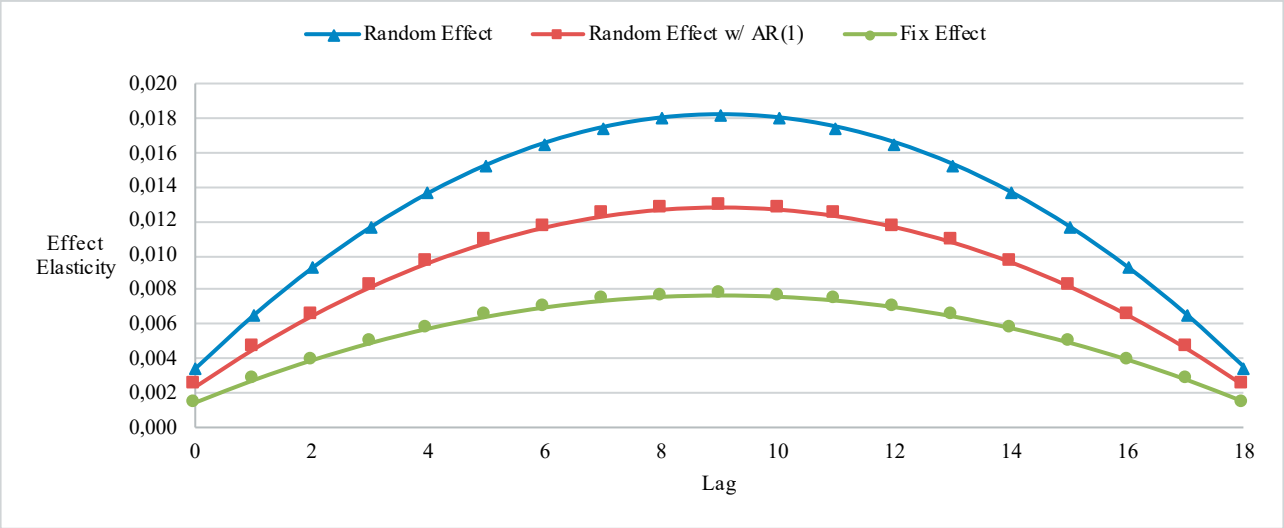

Figure 1. Distribution of single R&Dt-j effects in TFP specifications. Source: own elaboration. Note: FEff estimates are elasticities; REff estimates are marginal effects.

The estimated coefficients obtained from all specifications (both marginal effects and elasticities), beyond characterising and quantifying the relationship between R&D investments and productivity, are the fundamental elements of the assessment, via RoR, of the economic impact of R&D.

The measure of RoR is expressed as the MIRR that equates the marginal value of productivity to the unit value of research expenditure (RE). Depending on the regression results, the computed RoR for TFP specifications, shown in Table 4, follows the same variation in magnitude as the elasticity estimates.

In particular, the RoRs computed via the estimates obtained through the models employing the AR(1) component in the error term turn out to be smaller than the counterpart (w/o AR(1)).

The application of geometric means to TFP in the *log* specification yields higher returns, namely 9.13% vs 7.03% and 7.59% vs 6.58%.

This result is essentially due to a rebalancing of the average values of R&D lags. In particular, the geometric average, applied first to cross-country and then to lags, reduces the average value of the early lags and raises the values of the farther lags. Essentially, in this specific case, the geometric means flattened the R&D lags, by increasing the slope of the downward trend of the lag series. As related to the computation of the RoR, applying the geometric means to RE leads to the estimation of a higher contribution of past R&D to the present value of agricultural production.

The values of RoR obtained by including the AR(1) component in the error term ought to be considered as the most reliable, because they account for omitted variables having potential effects on the entire sample. However, the observed variation, from 7.0% to 6.6% for arithmetic means and from 9.1% to 7.6% for geometric means, do not change the magnitude of the estimated RoR in a meaningful way.

6. DISCUSSION

The RoR on investments in agricultural research in Europe is consistently positive across different analytical methods. However, our estimates are comparatively low with respect to most findings documented in the literature for developed countries. Moreover, the results confirm that RoR computation is sensitive to the specification of the models, the method applied to measure the variables, the lag length and its shape and the territorial coverage. In fact, if compared to other works, such as Schimmelpfennig et al. (2000a) (in the closed economy case), the RoRs obtained in this paper are to be considered very low. Indeed, these results might depend on several differences between our study and those used as a comparison, including the time period, and the relative length (1973-1993, in which agricultural productivity recorded high levels of TFP growth, vs 1981-2010), and a wider coverage of countries (we included Spain and

box, specific for the agricultural sector. For CAP, given the unavailability of country level data, we applied a dichotomous variable at year 1992 as proxy for the MacSharry reform.

Table 4. Computation of the Internal Rate of Returns (IRR) for the TFP specifications.

j	Variables in level form				Variables in logarithmic form									
					Arithmetic average					Geometric average				
	α PDL	VMP	α PDL (AR1)	VMP	RE	α PDL	VMP	α PDL (AR1)	VMP	RE	α PDL	VMP	α PDL (AR1)	VMP
0	0.004	0.04	0.002	0.03	183	0.001	0.02	0.001	0.02	115	0.001	0.03	0.001	0.02
1	0.007	0.08	0.005	0.06	182	0.003	0.03	0.002	0.04	115	0.003	0.05	0.002	0.05
2	0.009	0.11	0.007	0.08	181	0.004	0.05	0.004	0.06	114	0.004	0.07	0.004	0.07
3	0.012	0.14	0.008	0.10	179	0.005	0.06	0.004	0.08	114	0.005	0.09	0.004	0.08
4	0.014	0.17	0.010	0.12	178	0.006	0.07	0.005	0.09	113	0.006	0.11	0.005	0.10
5	0.015	0.19	0.011	0.13	147	0.006	0.10	0.006	0.11	113	0.006	0.12	0.006	0.11
6	0.017	0.20	0.012	0.14	141	0.007	0.11	0.006	0.12	112	0.007	0.13	0.006	0.12
7	0.018	0.21	0.012	0.15	135	0.007	0.12	0.007	0.12	112	0.007	0.14	0.007	0.13
8	0.018	0.22	0.013	0.16	129	0.008	0.13	0.007	0.13	111	0.008	0.14	0.007	0.13
9	0.018	0.22	0.013	0.16	124	0.008	0.14	0.007	0.13	111	0.008	0.15	0.007	0.13
10	0.018	0.22	0.013	0.16	118	0.008	0.14	0.007	0.13	110	0.008	0.15	0.007	0.13
11	0.018	0.21	0.012	0.15	112	0.007	0.15	0.007	0.12	110	0.007	0.14	0.007	0.13
12	0.017	0.20	0.012	0.14	107	0.007	0.15	0.006	0.12	110	0.007	0.13	0.006	0.12
13	0.015	0.19	0.011	0.13	101	0.006	0.14	0.006	0.11	109	0.006	0.12	0.006	0.11
14	0.014	0.17	0.010	0.12	95	0.006	0.13	0.005	0.10	109	0.006	0.11	0.005	0.10
15	0.012	0.14	0.008	0.10	90	0.005	0.12	0.004	0.09	109	0.005	0.09	0.004	0.09
16	0.009	0.11	0.007	0.08	84	0.004	0.10	0.004	0.07	109	0.004	0.08	0.004	0.07
17	0.007	0.08	0.005	0.06	78	0.003	0.08	0.002	0.06	110	0.003	0.05	0.002	0.05
18	0.004	0.04	0.002	0.03	72	0.001	0.05	0.001	0.03	109	0.001	0.03	0.001	0.03
MIRR	15.21%		9.51%			7.03%		6.58%			9.13%		7.59%	

Source: own elaborations

Portugal, the economies of which were lagging behind in 1973-1993, as well as Sweden, Finland and Norway, characterised by particular climatic conditions, limited agricultural activities and intensive use of advanced technologies).

Despite this, the RoRs resulting from the analyses might be deemed reasonable when considering that most of the agricultural research carried out across the European countries has the characteristic of being adaptive, rather than basic research. In this regard it is important to highlight that, beyond the methodology and the variable measurement, the RoRs are sensitive also to both the length and the shape of the lags elapsing between R&D and agricultural productivity, as shown by the differences obtained by applying arithmetic and geometric averages. In particular, further potential contributions could come from imposing a shape of fourth-order *PDL* (or positive-valued distribution function) with a positive skew in order to impute more weight on the effects of the early lags.

The results presented in this paper may suffer from potential limitations stemming from available data, namely GBAORD, which are a proxy of actual expenditure, and from the omission of unavailable information potential used as covariates. In fact, as suggested by the difference in the results due to omitted variables, despite the general goodness and robustness of the estimations, model specifications are susceptible to improvements by including and controlling for more variables, especially those likely affecting agricultural productivity in direct ways unlinked to own-country agricultural research, such as evolution of farm structure, spill overs, weather, trade flow and agricultural policy.

In particular, including aspects regarding the CAP reforms and accounting for spill overs as well as climate evolution could potentially modify the results. Further, the availability of data on private expenditures on agricultural R&D and the use of longer and more complete time series might have furtherly increased the robustness of the results. The consideration of these variables in this paper was explored, but the results were not satisfactory, most likely due to limitations in data availability. In any case, even if data had been available their use would also have required a reformulation of the analytical models in a consistent way.

In perspective, if data become available, different strategies may be envisaged to improve this study. The correctness of the model specifications and, hence, the robustness of the results would largely benefit from a wider analytical approach that is able to consider the modern transformations occurring in the European agricultural sector. We refer, in particular, to the growing interest of research, including agricultural research, and policies, especially the CAP, towards the development of technologies, practices and measures devoted to aims other than productivity, such as improving environmental protection, food safety and climate change mitigation.

However, the impact of these variables is not straightforward. For example, the CAP, on the one hand promotes innovation measures accelerating the transfer of research results to farmers, and on the other hand includes measures aimed at improving the sustainability of agricultural production processes but that indirectly might induce the effects of moderating the productivity. As a result, the direction of this impact is an empirical issue and may be correctly accounted for only by disentangling the effects of different measures.

Moreover, agricultural productivity itself as a focus of analysis ought to be revisited. Indeed, it is not only productivity, by the means of research, that brings about benefits to society. Other measures able to contemplate the effects of research on side aspects related to the agricultural production processes could be investigated, such as the societal value of the provision of public goods or the environmental protection, such that even the relative RoR would be much more representative of broader research efforts.

All these aspects and dynamics require a deeper analysis and could be the subject of further investigations in the years to come, especially as they would need better data than those currently available.

7. CONCLUSIONS

In this paper we analyse the impact of public R&D on agricultural productivity at the aggregate level, by using data from 16 countries, that can be considered as representative, in aggregated terms, of the European agricultural sector. Based on this, we estimate the RoR of public research expenditure in Europe. Our results add updated empirical information on the topic, by widening both the period of analysis and the territorial coverage at the European level as compared to existing studies.

The results corroborate the hypothesis that, on average, research expenditure has a generally positive impact on productivity, which yields a relevant RoR. Our estimates show returns of public R&D investments on agricultural productivity of between 6.5% and 15.2%, varying according to model specifications and computation techniques. These results are consistent with other estimates from the literature, though lower than results from the US. The time lags are shorter than reported by most of the US literature.

The general policy message from this paper is that the return on public research expenditure justifies investments in agricultural research, especially considering the low return from alternative investments in the current stage of the economic cycle. At the same time, the level and variability of return according to different estimation methods and different countries/sectors hints at the need for a careful evaluation of expenditures at the stage of programme/project funding. This would require a more detailed *ex-ante* evaluation of expected returns, but also attention to the widest range of priorities by policies (beyond productivity), more attention to targeting of expenditure as well as greater attention to factors that enable fast and effective research impact. This is indeed the route taken by current R&D funding policies at the European level.

The analysis has limitations related to data availability, especially concerning research expenditure. The main limitations concern the length of the available time series and the level of standardisation (comparability over time and space) of expenditure data. This also reflects on the methodological approach used, as the study was carried out by employing the most suitable methodology able to accommodate both the quality and availability of panel data.

In spite of the wide room for improvement, this work should be useful as a reference basis for further studies, especially for evaluating the impact of private R&D investments, the role of spill-overs as well as the effects of CAP reforms on agricultural productivity, both at the country and European levels. An additional pathway for further research is to take into account the diversity characterising the research policies of different European countries. A satisfactory exploration of these routes will require consistent improvements in the availability of methodologies and datasets, with a strong priority for the latter.

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