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Research article

How does the land market capitalize environmental, historical and cultural components in rural areas? Evidences from Italy

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ABSTRACT

Farmland can supply a wide variety of ecosystem services, i.e. provision of food and fibre, as well as regulating, supporting, recreational, aesthetic and cultural services. In addition, farmland can be characterized by the presence of anthropic elements, i.e. archaeological sites and historical rural buildings, from which the community can obtain further non-material benefits, namely cultural heritage values, recreation and tourism, etc. However, all these services and land components can be strongly influenced by different levels of farming intensity, a condition that can damage their capacity to supply the related functions (public goods). Such land-market failures could be adjusted by acquiring information on how the above non-farming characteristics, i.e. environmental, historical and cultural determinants, are capitalized in farmland value when farming intensity varies.

To this aim, a real estate survey was carried out in Italy in order to investigate the land market of traded farms cultivated under specific crops and located in two areas with different levels of farming intensity. The analysis considered farming and non-farming determinants of selling price and used a hedonic model method based on the ordinary least squares regression corrected for spatial autocorrelation. The results highlighted that the farming determinants were capitalized in selling price as expected in both areas, while the impacts of the non-farming characteristics were extremely diversified between the areas. In the extensively farmed area, the environmental, historical and cultural determinants tended to be positively capitalized, thus favouring their preservation. However, in the intensively farmed area, these were positively or negatively capitalized according to whether or not their overexploitation could allow increased yields, respectively. In yet other cases, some non-farming determinants were not capitalized at all in either area. These trends provided useful insights for the design of *ad hoc* market-based schemes able to enhance land market functioning and the maintenance of these components in agricultural areas with different levels of farming intensity.

1. Introduction

Farmland covers 40% of the world's land area (FAOSTAT, 2016) and is mostly used to produce food and fibres. In addition, it supplies residential spaces and natural amenities, and allows the interaction between agricultural ecosystems and terrestrial/aquatic ecosystems. Thus, farmland can supply a wide variety of ecosystem services (ES), namely the benefits people obtain from ecosystems. In general, these are classified into four categories (Millennium Ecosystem Assessment, 2003): provisioning ES, concerning the provision of agricultural products such as food, fibre and biofuel; regulating ES, deriving from processes that regulate quality and quantity of water, climate and pest populations; recreational, aesthetic and cultural ES, supplied by natural resources and landscapes in agricultural ecosystems; supporting ES, i.e. soil formation, nutrient cycling and genetic biodiversity, which underpin the previous three and enable their existence and dynamics. Provisioning and regulating ES contribute to agricultural production (Zhang et al., 2007), while recreational, aesthetic and cultural ES ensure natural amenities concerning open space for rural residents, as well as recreational activities (e.g. rural tourism, fishing and hunting) and landscape for the community. Furthermore, ES from farmland contribute towards the preservation of natural elements located outside the agricultural areas, i.e. lakes, wetlands and forests (Knoche and Lupi, 2007). Therefore, farmland provides private and public functions through ES

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(Henneberry and Barrows, 1990; Xu et al., 1993) so that, in addition to use values, it has option and non-use values that are rarely considered by the farmland market (Palmquist, 1989). Regulating, recreational, aesthetic and cultural ES are public goods that often lack markets, although they improve the quality of life and contribute to the production of marketable goods, unless they are involved in public policies able to create special property rights that bring out their value (e.g. greenhouse gas mitigation) (Ma and Swinton, 2011). These considerations can also be formulated for other anthropic elements located on farmland, i.e. archaeological sites and historical rural buildings, from which the community can obtain further non-material benefits related to cultural heritage values, recreation and tourism, knowledge systems, educational values, etc. However, also in these cases, such important components often lack markets.

The supply of environmental, historical and cultural benefits via natural and anthropic territorial elements that ensure the achievement of several human objectives could be seriously influenced by farming intensity (Newton, 2004). Intensive farming is based on limited crop rotations and on cultivation practices carried out through quantities of productive factors (capital and labour) and inputs (fertilizers, pesticides and herbicides, irrigation water, fuel and power) per unit area that can be much higher compared to the extensive farming. Its main aim is to maximize revenue through high production levels, while the preservation and management of ecosystems and anthropic elements are marginal issues (Pe'er et al., 2014), so damaging the capacity of these public goods to supply the related services.

These considerations highlight land-market failures, which could be adjusted by acquiring knowledge of the farming and non-farming drivers operating in specific areas with different cropping systems and farming intensities. The information could be provided by the farmland market, and in particular through the investigation of how environmental (ES), historical and cultural determinants are capitalized in farmland value (Ma and Swinton, 2011). Such knowledge makes it possible to investigate the opportunities and threats for these components in agricultural areas, favouring the creation of market-based schemes for their efficient allocation and conservation (Kroeger and Casey, 2007).

This study aims i) to investigate how environmental, historical and cultural territorial components affect farmland value ii) in two different Italian areas characterized by extensive and intensive farming system iii) by focusing on three cropping systems (cereal fields; olive groves for the production of olive oil; vineyards for the production of wine). This approach could allow the investigation and the setting of *ad hoc* market-based schemes for an efficient allocation and conservation of these components in agricultural areas with different farming intensities (Kroeger and Casey, 2007).

2. Literature review on the determinants of farmland value

Land productivity is the most important driver of farmland value, and its assessment through the discounted flow of expected returns is a widespread approach (Ricardo, 1817; Gardner, 1987; Wineman and Jayne, 2018). However, this tends to fail in the short term (Awasthi, 2014), due to the exclusion of other use values and non-use values, i.e. existence and bequest values (Awasthi, 2012). Furthermore, several market conditions that are the most important long-term determinants of farmland value (Falk and Lee, 1998) are disregarded, namely cyclic fluctuations (Awasthi, 2012), bubbles (Featherstone and Baker, 1987), time-varying risk premiums (Hanson and Myers, 1995), overreaction (Burt, 1986; Irwin and Coiling, 1990), fads (Falk and Lee, 1998), risk aversion and transaction costs (Just and Miranowski, 1993; Chavas and Thomas, 1999). Thus, the discounting method tends to provide unreliable assessments.

In contrast, hedonic analysis, i.e. a revealed preference valuation method, uses regression techniques to investigate the effects of changes in specific land characteristics on farmland prices by inferring the marginal prices. This approach makes it possible to consider further factors driving farmland values, such as soil characteristics (Patton and McErlean, 2003; Choumert and Phélinas, 2015), climate trends and land elevation (Mendelsohn et al., 1994; Maddison, 2000), proximity to agricultural markets (Von Thünen, 1842; Merry et al., 2008) and plot size (Wineman and Jayne, 2018). However, farmland value is not only related to its current use but also to its potential uses (Plantinga et al., 2002), thus it is also affected by non-agricultural factors. These include proximity to urban areas (Goodwin et al., 2003; Sklenicka et al., 2013), which influences the conversion of farmland to urban uses and increases its value for future urban expansion (Plantinga et al., 2002; Livanis et al., 2006), the tenure status of farmland (Choumert and Phélinas, 2015), and local population density and growth (Maddison, 2000; Huang et al., 2006). These aspects are so important that in the United States, for example, non-agricultural factors account for one quarter of the average farmland value (Barnard, 2000), thus influencing farmland value more than farm returns (Hardie et al., 2001). Several studies also analyse aspects of agricultural programme payments in Europe (Weersink et al., 1999; Goodwin et al., 2003), such as the influence of the decoupling reform on agricultural production (Rude, 2008), investment decisions (Sckokai and Moro, 2009) and aspects concerning income distribution (Latruffe and Mouël, 2009). Analysis of the literature highlights that the influence of environmental, historical and cultural determinants on farmland value has not been adequately analysed by scholars, and the study of Ma and Swinton (2011) in the United States is the only one concerning the depiction of ES value from landscapes and resources on agricultural lands and surrounding areas. However, it is important to investigate how these determinants are capitalized by the land market, especially since cropping systems and farming intensity change in specific rural areas.

3. Materials and methods

This section firstly describes the study areas by focusing both on the considered crops and on the production factors and inputs used for the related cultivation practices. Successively, it explains the approach used for the detection of the farming and non-farming determinants affecting the land value, i.e. the focus group, as well as the sources used for gathering the related data. Finally, the formalization of the models based on the accounting of spatial dependence among the traded properties is presented.

3.1. The study areas

Within the framework of the European Rural Development Policy for 2014–2020 (European Commission, 2013; Noack and Schüler, 2020), regional municipalities are classified in four different categories: rural areas with specialised intensive agriculture, intermediate rural areas, rural areas with development problems, and urban/peri-urban areas. This classification allows the territorialisation of policy measures according to the needs of different types of area. Indeed, zoning is used to implement the Rural Development Programmes (RDPs) of the Italian regions and the National Strategic Framework (NSF) for cohesion policy (European Commission, 2014).

According to this classification, the present study focuses on two types of rural areas, both located in Foggia Province (Apulia Region, southern Italy) (Fig. 1), but characterized by different farming intensity. The first (Area A) is a rural area with development problems, and consists of 28 municipalities on a utilized agricultural area (UAA) of 124,000 ha. It includes hilly and arid inland areas, covered with woods and natural pastures and crossed by rivers, with a large number of scenic sites related to the Daunia Mountains. The main crops are cereals (mainly durum wheat), which are grown on 89% of the UAA, followed by olives on 4% and wine grapes on 3% (National Census on agriculture, 2010). The second area (Area B) consists of 13 municipalities on an UAA of 211,000 ha. It is fertile and flat, with few natural or landscape

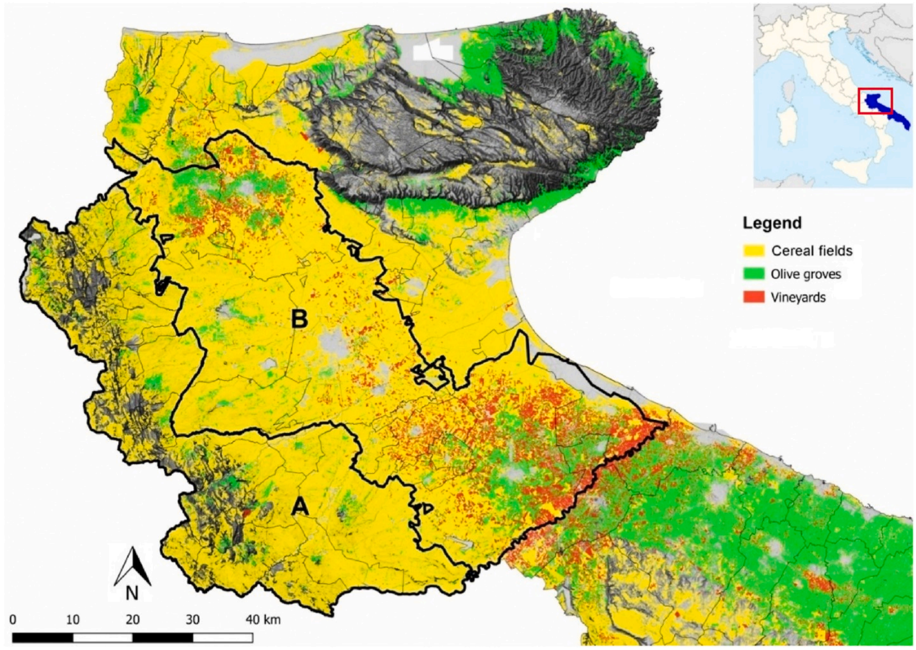

Fig. 1. The study areas: A - Rural area with development problems; B - rural areas with specialised intensive agriculture.

components. Cereals are grown on 53% of the UAA, olive groves on 11% and vineyards on 14%.

In general, crops in Area A are cultivated using extensive agricultural practices that involve modest use of both productive factors, i.e. capital and labour, and technical inputs, i.e. fertilizers, pesticides, irrigation water, fuel, etc., per hectare. In contrast, crops in Area B are produced using intensive agricultural practices that make massive use of productive factors and technical inputs. Concerning the crops considered in this study (cereals, olives and grapes), there are no appreciable differences between the two areas in the agricultural practices used for cereal fields. In contrast, olive groves in the Area B have a higher tree density (>200 trees/ha), and their management involves more frequent tillage (>3/year), together with greater quantities of irrigation water (>500 m^3/ha/year), pesticides, fertilizers, power and fuel (+80%). Finally, vineyards in the two areas are based on two very different production systems:

a) Area A – prevalence of the extensive "*Espalier*" system, based on two vine-shoots per vine, with medium-low yields (9–16 t ha^{-1}) obtained using local varieties and a moderate level of inputs; this is mainly found in the inland, hilly and arid territories of Foggia Province, and is often used to produce wine with EU quality certifications, i.e. Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI);
b) Area B – prevalence of the intensive "*Tendone*" system, with several vine-shoots per vine (even more than four), with sizeable yields per hectare (up to four/five-times greater than the extensive system) obtained using more productive varieties and higher levels of inputs; this is widespread in the flat and fertile territories, and is often used to produce table wine.

Therefore, the level of farming intensity varies between the study areas, but also among the considered crops in each area.

3.2. Variables and data collection

The farming determinants of land value in the two study areas were identified through a focus group, an essential method for discussing concepts and investigating scenarios in social sciences (Chilton and Hutchinson, 1999). It was held at the University of Foggia in October 2018, and involved local lawyers (2), brokers (3) and farmers (3), i.e. a number of individuals between 6 and 10, as suggested in the literature (Krueger and Casey, 2000). Just one discussion meeting was necessary due to the participants' familiarity of the farmland market. Indeed, the people at the meeting constituted a convenience (non-random) sample due to their involvement and/or knowledge of farmland market in the two investigated areas, so ensuring the participation of a representative sample of stakeholders from different backgrounds (Quick and Zhao, 2011). One month before the meeting, participants were invited with an email providing the description of the research and the topic of discussion (Stewart and Shamdasani, 2014). A recruitment letter containing more information on the discussion topic was then distributed to all participants two weeks later, allowing them to begin considering the topics for discussion (Pyrialakou et al., 2019). The focus group meeting was designed to last approximately 60 min, and was led by a moderator, i.e. one of the co-authors of this study. The conversation was based on the following discussion topics: i) farming and non-farming determinants of land value in the two study areas; ii) impacts of intensity farming on land value in the two study areas. The discussion was recorded and transcribed verbatim. All transcripts were returned to participants for comment.

Thus, jointly to the analysis of the literature, it emerged that selling price (*Selling price* -,000 € ha^{-1}) was strongly affected by the following characteristics (Table 1): farmland area (*Size* - ha), which is related to economies of scale mainly concerning labour and capital; yield (*Yield* – tonne ha^{-1}), which indicates soil fertility and is related to income from cereal fields; age of plants (*Age* - years), which influences yield and quality of produce in olive groves and vineyards; terrain slope (*Slope* - %), which affects mechanized activities and is related to hydrogeological risk, especially in inland Area A (Roselli et al., 2009); distance between the nearest urban centre and the property (*Distance* - km), which impacts on the speed of transport of commodities to/from markets, as well as on accessibility to schools, hospitals, etc.; the location of farmland along highways or regional/provincial roads (*Road* - Yes/No), which is related to the same aspects concerning the distance variable, but also to possible land urbanization dynamics. In general, farmers in the two areas had a similar appreciation of these determinants, so that the following were considered as increasing selling price: a larger land area, higher yields, terrain with less of a slope, closer proximity to the

Table 1
Land value determinants of cereal fields, per study area.

Variable	Unit	Area A (Rural area with development problems) Cereal fields (n = 119)					Area B (Rural area with specialised intensive agriculture) Cereal fields (n = 156)					*t*-test/χ^2 test sign.
		Min.	Max.	Mean	St. dev.	Expect. sign	Min.	Max.	Mean	St. dev.	Expect. sign	
Selling price (,000)	€ ha^{-1}	20,593.23	27,821.57	23,502.33	12,832.04		23,843.40	33,384.71	28,743.53	18,482.19		***
Farming characteristics												
Size	ha	1.32	26.12	4.42	6.80	+	0.82	44.17	5.62	5.95	+	***
Yield	t ha^{-1}	2.37	3.78	3.09	1.44	+	3.30	4.46	4.11	3.13	+	***
Age	Years	–	–	–	–		–	–	–	–		
Slope	%	1.87	9.36	6.27	7.32	–	1.12	7.83	3.71	4.52	–	***
Distance	km	2.33	19.80	7.32	8.39	–	3.59	18.72	10.60	9.48	–	***
Road	Yes/No	0	1	0.13	0.10	+	0	1	0.28	0.18	+	***
Environmental, historical and cultural characteristics												
River	km	0.70	7.33	3.33	5.41	–	0.92	9.18	4.55	2.65	+/−	***
Woodland	km	0.52	4.44	1.72	6.26	–	1.07	7.48	4.17	4.88	–	***
Groundwater	Yes/No	0	1	0.33	0.47	+	0	1	0.92	0.66	+	***
Irrigation network	Yes/No	0	1	0.62	0.58	+	0	1	0.91	0.70	+	***
Scenic site	km	0	2.35	1.91	3.79	+	0	4.18	3.52	4.61	+/−	***
Historical site	km	0.38	8.10	4.18	6.22	+	1.14	9.62	6.33	3.25	–	***
Building	Yes/No	0	1	0.09	0.17	+	0	1	0.14	0.13	–	***

* Sign. 10%; ** Sign. 5%; *** Sign. 1%.

nearest urban centre, and proximity to a road. The only exception concerned the age of vines in vineyards since older vines in area A enhanced wine quality, while in area B decrease yields.

In addition to the farming characteristics, a set of environmental determinants related to ES was also identified. In this connection, in order to quantify the impact of ES on farmland value, first-best measures are suitable for measuring their productivity. However, at present, this type of information is either expensive to obtain or else cannot be measured. Indicators on the agricultural ES have now become available at EU scale, mainly provided by the monitoring of the Common Agricultural Policy (CAP). However, this type of study firstly requires parcel-based data to which access is often restricted. Secondly, the available indicators for agroecosystems are mainly for soil-related services, such as erosion control and nitrogen fixation, while data related to other important services for sustaining agricultural production, for example pollination data, are becoming available only now for their use in the assessment practice. Finally, only a few indicators are available for cultural ecosystem services, so that more efforts are needed to provide high-quality data in this field (Maes et al., 2016). Furthermore, most ES are jointly supplied by ecosystems generated by the same cropping system, so causing collinearity issues. Consequently, since ES are generated by environmental resources located near farmland, the proximity of the traded properties to these resources can represent a valid proxy variable for ES (Ma and Swinton, 2011). Moreover, it emerged from the focus group that precisely this proximity is the criterion used by local property traders. Consequently the following environmental determinants were considered: proximity to rivers (*River* – kilometres); proximity to woodlands, wetlands, parks and natural reserves (*Woodland* – km); use of groundwater for irrigation (*Groundwater* - Yes/No); use of public irrigation networks (*Irrigation network* - Yes/No); proximity to scenic sites (*Scenic site* – km), i.e. preserved areas identified via the regional Territorial Landscape Plan (TLP) (Regione Puglia, 2015) and including natural elements which are components of the Apulian landscapes, whose importance is also related to international notoriety and tourist attractiveness. Concerning these environmental determinants, natural water elements foster recreational activities (i.e. fishing and boating) and provide views, regulate water resources, and host beneficial fauna (insects). Although farmland near these environmental components runs a higher risk of floods damaging harvests and plantations, it also allows farmers to use large quantities of water for irrigation, thereby causing serious damage to these ecosystems (MEA, 2005). The presence of nearby woodlands, wetlands, parks and natural reserves indicates possible habitats for beneficial flora and fauna, and allows recreational activities in the area, like hunting and hiking (Ma, 2010). However, some wild species (i.e. boars and starlings), together with pests and wildfires, could damage plantations near these natural components. On the other hand, agricultural practices, i.e. pest control and ploughing, could damage wild flora and fauna species living in woodlands, wetlands, parks and natural reserves. Groundwater ecosystems provide important services, such as water purification and storage over time, drinking water supplies, active biodegradation of anthropogenic contaminants, inactivation and elimination of pathogens, nutrient recycling, mitigation of floods and droughts, preservation of biodiversity or rare and endemic species, and provision of recreational, spiritual and tourist sites (Griebler and Avramov, 2015). The availability of this important resource in agriculture ensures higher yields and prevents drought stress to crop plants. However, its excessive use can lead to aquifer salinization and contribute to desertification (MEA, 2005). Similar benefits are provided by public irrigation networks, which distribute irrigation water to farms mostly from rivers and dams, thus contributing to the recharge of groundwater in aquifers, the formation of wetlands, landscape fruition, and the buffering of floods and droughts.

Finally, the focus group also highlighted the impact of historical and cultural determinants on land value by considering the proximity of farmland to historical and archaeological sites in rural areas (*Historical site* - km), and the presence of traditional rural buildings (*Building*). In particular, the relationship between farming practices and historical or archaeological sites, even in scenic spaces, generates cultural and recreational activities for the community (MEA, 2005). However, some agricultural practices, mainly regarding intensive farming and related to soil tillage and pest control, may interfere with recreational activities, so that these are often monitored, and in some cases prohibited by national and regional laws. Therefore, the proximity of farmland to these sites could represent a serious constraint to agricultural practices. The traditional rural buildings, instead, are components of both the rural landscape and rural cultural heritage. These constructions can provide a variety of public benefits, such as historical, social, aesthetic, spiritual, cultural and educational values and shared experience, thus contributing to social welfare (Choi et al., 2010; Cucari et al., 2019). Farmers of the past used these structures as temporary or fixed homes, harvest storehouses, look-out posts, animal shelters, etc. However, especially in the intensive area, the market related to traditional rural buildings, i.e. the farmland market, does not reflect the real value the community attaches to these goods and to the related services. Land transactions mainly focus on productive aspects, while farmers consider rural buildings a nuisance, often leaving them in poor conditions or even abandoned. The expected signs between selling price and each farming, environmental, historical and cultural variable, per cropping system and area, are showed in Table 1.

Data concerning all the above variables refer to transactions between January 2014 and November 2018, which was a relatively stable period for the local farmland market, and were surveyed through several sources. In particular, *Selling price*, *Size* and *Building* variables were collected from estate agencies, while *Yield, Age, Groundwater* and *Irrigation network* variables were gathered through face-to-face questionnaire-based interviews of approximately 15 min with the properties' sellers. *Distance* and *Road* variables were measured using Google Maps. Finally, *Slope*, *River*, *Woodland*, *Scenic site* and *Historical site* variables, as well as the geographic data of the traded properties, were obtained through the territorial information system of Apulia Region (SIT Puglia, 2020). Missing data, concerning 13 traded properties and relating to *Groundwater* and *Irrigation network* variables, were gathered by direct inspection. In total, the study used one sample per cropping system and study area (Tables 1–3). The survey was carried out from November 2018 to June 2019.

3.3. The model

The data surveyed were used to perform a hedonic analysis, based on Lancaster's theory (1966). The basic assumption is that consumers derive utility by the characteristics of goods. This approach is the classic theoretical foundation for the hedonic model concerning individual choices in market equilibrium (Rosen, 1974). In the case of farmland market, let $A = (a_1, a_2, \ldots a_n)$ denote n farming and non-farming attributes of farmland and P its price, so that $P = h(A)$, where $h(\cdot)$ represents the functional relationship between the farmland price and its attributes (Palmquist, 1991; Ready and Abdalla, 2005). The regression of prices P on farmland attributes allows the assessment of the marginal values, i.e. the implicit price that buyers would pay for a unit change in each attribute, so that $\widehat{P}_i = \partial\widehat{h}(A)/\partial a_i$. Thus, the following stochastic equation was assumed:

$$\ln P = \beta_0 + \sum \beta_f F + \sum \beta_e E + \sum \beta_h H + \sum \beta_c C + \varepsilon \tag{1}$$

where: P is the selling price of farmland, F, E, H and C are the vectors of farming, environmental, historical and cultural characteristics, respectively, β_0, β_f, β_e, β_h, β_c are the respective unknown coefficients to be estimated, and ε is the error term.

The assessment was based on the ordinary least squares (OLS) regression, which identifies the coefficients of the farming and non-farming attributes in a linear function by the principle of least squares, i.e. by minimizing the sum of the squares of the differences between the observed and the predicted farmland prices (Greene, 2018). With regard to the selection of the functional form, the one-parameter Box-Cox transformation for the dependent variable was used. It is a particular family of power transform based on power functions that mainly allows to stabilize variance and to normalize the data (Box and Cox, 1964). Several power parameters λ between −3 and 3 were tested, and the optimal one was selected by using a maximum likelihood criterion. Thus, a log form of the dependent variable was selected ($\lambda = 0$), and a semilog functional form of the model was used. In this way, the natural logarithm of farmland price was regressed on the vectors of untransformed independent variables. This functional form assessed the percentage variation in selling price for an absolute change in each regressor by multiplying the relative change in selling price by 100. That is to say, $\widehat{\beta}$sx 100 gave the variation rate in selling price, though the transformation proposed by Halvorsen and Palmquist (1980) provided a more precise estimate, namely $\exp(\widehat{\beta}) - 1$. This model allowed the direct assessment of the appreciation rates related to the considered characteristics, thus providing insights for the understanding of farmland market dynamics in the presence of different types of determinants.

Since the study concerned the evaluation of land properties distributed over the territory, a good practice concerns the accounting of spatial dependence that can occur in the dependent variable due to spillover effects, i.e. when selling prices are influenced by prices obtained in neighbouring territories. This effect is due both to competition among buyers for land within a radius around their farms and to the use of reference prices by property owners and buyers in the same region (Maddison, 2009). Therefore, the selling prices of geographically close areas of farmland tend to be similar because of the spatial dependence of properties, and this tendency among observations cannot be ignored in the estimation of unbiased regression coefficients (Anselin, 1988; LeSage and Pace, 2009). Indeed, many studies concerning the farmland market have proved the presence of spatial effects (Patton and McErlean, 2003; Huang et al., 2006; Ma and Swinton, 2011; Ma and Swinton, 2012; Dillard et al., 2013; Hüttel and Wildermann, 2015; Lehn and Bahrs, 2018a, 2018b).

In order to account for spatial dependence, spatial autocorrelation in data and regression residual was tested using Moran's I test. A positively significant value of this index indicates similarity between the selling price at each location and the selling prices at locations which are spatially near (Anselin and Hudak, 1992). The analysis confirmed the existence of spatial autocorrelation in the two samples,[1] and the robust version of the Lagrange multiplier (LM) test indicated that it was necessary to consider spatial dependence in the dependent variable.[2] Thus, spatial heterogeneity concerning the spatial variation in relationships was considered (LeSage, 1998), and a spatial error model was estimated with an inverse distance-weighting matrix W, by assuming in the expression (1) (Anselin, 1988; LeSage and Pace, 2009):

$$\varepsilon = (I - \lambda W)^{-1}\mu \tag{2}$$

where λ is a spatial lag coefficient related to the spatial autoregressive parameter, μ is a vector of homoscedastic and uncorrelated errors, and the spatial weight matrix W concerns the proximity of each property to those near. Its weights are the inverse distances between properties, so that the strength of neighbouring relationships decreases with distance (Lehn and Bahrs, 2018a; Bivand et al., 2013). In this connection, a cut-off distance within which the neighbouring prices influence each other was set (Lynch and Lovell, 2002) using Moran's I spatial correlogram (Ma and Swinton, 2011). It suggested significant spatial correlation among observations in a distance band,[3] so that an inverse

[1] In the extensive area, Moran's I is: 0.814 ($P < 0.000$) for cereal fields; 0.572 ($P < 0.000$) for olive groves; 0.449 ($P < 0.000$) for vineyards. In the intensive area, Moran's I is: 0.647 ($P < 0.000$) for cereal fields; 0.601 ($P < 0.000$) for olive groves; 0.724 ($P < 0.000$) for vineyards.

[2] In the extensive area, Robust LM for spatial lag is: 173.70 ($P < 0.000$) for cereal fields; 114.81 ($P < 0.000$) for olive groves; 120.92 ($P < 0.000$) for vineyards. In the intensive area, Robust LM for spatial lag is: 196.11 ($P < 0.000$) for cereal fields; 148.17 ($P < 0.000$) for olive groves; 166.10 ($P < 0.000$) for vineyards.

[3] Area A - Cereal field: distance band 0.60–3.20 km; cut-off point 1.90 km. Olive groves: distance band 0.40–2.20 km; cut-off point 1.30 km; Vineyards: distance band 0.20–1.50 km; cut-off point 0.85 km.Area B - Cereal fields: distance band 0.50–2.60 km; cut-off point 1.55 km. Olive groves: distance band 0.20–1.70 km; cut-off point 0.95 km. Vineyards: distance band 0.20–0.80 km; cut-off point 0.50 km.

Table 2
Land value determinants of olive groves, per study area.

Variable	Unit	Area A (Rural area with development problems) Olive groves (n = 106)					Area B (Rural areas with specialised intensive agriculture) Olive groves (n = 116)					t-test/χ^2 test sign.
		Min.	Max.	Mean	St. dev.	Expect. sign	Min.	Max.	Mean	St. dev.	Expect. sign	
Selling price (,000)	€ ha^{-1}	20,452.64	39.451.07	32,461.53	22,451.92		27,832.37	47,932.28	37,576.61	18,362.49		***
Farming characteristics												
Size	ha	1.31	9.66	3.75	1.94	+	2.16	29.38	4.19	3.06	+	**
Yield	t ha^{-1}	–	–	–	–		–	–	–	–		
Age	Years	26	82	58.18	39.70	+	22	88	67.47	36.95	+	***
Slope	%	2.22	7.80	4.55	2.86	–	1.47	5.39	3.58	1.11	–	***
Distance	km	1.29	17.00	7.10	4.53	–	2.88	21.54	13.30	6.44	–	***
Road	Yes/No	0	1	0.15	0.06	+	0	1	0.26	0.13	+	**
Environmental, historical and cultural characteristics												
River	km	0.62	8.83	3.02	5.41	–	1.02	9.44	5.14	4.27	+/–	**
Woodland	km	0.84	4.10	2.18	6.26	–	1.52	8.30	4.49	2.15	–	***
Groundwater	Yes/No	0	1	0.46	0.35	+	0	1	0.95	0.67	+	***
Irrigation network	Yes/No	0	1	0.64	0.49	+	0	1	0.91	0.73	+	***
Scenic site	km	0	3.77	2.16	4.13	+	0	4.97	3.71	5.82	+/–	***
Historical site	km	0.24	9.27	3.03	7.39	+	0.66	10.00	4.16	4.19	–	**
Building	Yes/No	0	1	0.13	0.06	+	0	1	0.10	0.08	–	***

* Sign. 10%; ** Sign. 5%; *** Sign. 1%.

Table 3
Land value determinants of vineyards, per study area.

Variable	Unit	Area A (Rural area with development problems) Vineyards (n = 94)					Area B (Rural area with specialised intensive agriculture) Vineyards (n = 151)					t-test/χ^2 test sign.
		Min.	Max.	Mean	St. dev.	Expect. sign	Min.	Max.	Mean	St. dev.	Expect. sign	
Selling price (,000)	€ ha^{-1}	32,238.75	65,719.40	53,060.57	29,377.00		41,784.18	67,311.71	58,809.54	23,035.39		***
Farming characteristics												
Size	ha	0.67	13.28	2.19	9.19	+	0.76	17.62	3.72	5.42	+	**
Yield	t ha^{-1}	–	–	–	–		–	–	–	–		
Age	Years	4	26	18.20	12.95	+	6	19	12.53	9.41	–	***
Slope	%	1.07	6.15	3.12	4.10	–	1.26	5.03	3.04	3.40	–	***
Distance	km	3.63	17.26	9.65	13.83	–	2.17	17.48	11.11	12.20	–	***
Road	Yes/No	0	1	0.16	0.26	+	0	1	0.21	0.23	+	***
Environmental, historical and cultural characteristics												
River	km	0.39	8.14	3.05	4.10	–	1.81	10.47	5.10	3.93	+/–	***
Woodland	km	0.85	4.96	3.68	7.19	–	1.22	6.55	4.17	4.88	–	***
Groundwater	Yes/No	0	1	0.58	0.63	+	0	1	0.98	0.31	+	***
Irrigation network	Yes/No	0	1	0.67	0.46	+	0	1	0.90	0.66	+	***
Scenic site	km	0	3.35	1.91	3.79	+	0	5.18	3.52	4.61	+/–	***
Historical site	km	0.38	7.10	4.18	6.22	+	1.14	8.62	5.39	3.48	–	***
Building	Yes/No	0	1	0.13	0.07	+	0	1	0.09	0.04	–	***

* Sign. 10%; ** Sign. 5%; *** Sign. 1%.

distance-weighting matrix with a specific cut-off point from the centroid of each farmland was generated, per sample.

Regression diagnostics were carried out on multicollinearity (variance inflation factor - VIF), as well as on the normality (Shapiro–Wilk test), homoscedasticity (Breusch-Pagan test), and no autocorrelation of residuals (Durbin–Watson test) (Gujarati and Porter, 2009).

Finally, the difference of the regression coefficients between the two areas and per cropping system was verified. In particular, the null hypothesis H_0: $\beta_A = \beta_B$, was tested, where β_A is the regression coefficient of each significant variable for each cropping system in extensive Area A, and β_B is the equivalent regression coefficient in intensive Area B. To this aim, firstly a dummy area variable was created, coded as 1 for Area A and 0 for Area B. Then, the interaction variables between the area variable and each determinant were created and inserted as predictors in the regression equation. Results indicated that the regression coefficients β_As were significantly different from β_Bs. Therefore, the null hypothesis $H_{0,}$ related to no difference in the determinants between the two areas, was refused.

4. Results

4.1. Characteristics of the traded properties

The characteristics of the traded properties differ between the study areas, and their significance is demonstrated by the *t*-test and the chi-squared test, depending on the type of variable (Tables 1–3). In particular, farmlands in Area A are sold at lower prices because of their lower productivity, which is also caused by the poor soil fertility of the sloping hilly territories. These properties are smaller for the significant impact of land fragmentation, and their distance from the nearest urban centre is shorter due to the slighter size of the municipal areas in the hilly territories, where road infrastructures are less widespread for the adverse orography. With regard to environmental characteristics, properties in Area A lie closer to rivers, woodlands, and scenic sites because these natural elements are more widespread in the hilly inland territory. In Area B private wells and public irrigation networks are on over 90% of the properties, since both sources are often used to ensure crops a greater water supply. In contrast, the public irrigation network covers just two-thirds of the traded farmlands in Area A, while on average 46% of properties use groundwater from private wells. Therefore, less irrigation water is available in Area A due to the higher costs of constructing irrigation networks and drilling wells. Finally, the traded properties in Area A are closer to historical sites, and are characterized by a greater presence of rural buildings, except for the cereal fields.

4.2. Farmland market results

The results highlight a good fitting of the models, as shown by the adjusted R-square comprised between 60% and 79%, and the significance of the F tests at 1% (Table 4, Table 5, Table 6). The VIF values (not shown in tables), comprised between 1.18 and 1.75, exclude collinearity problems of predictors as much lower than the thresholds commonly used by analysts, i.e. 5 or even 10, according to Snee (1973) and Marquandt (1980), respectively. Moreover, the Shapiro–Wilk test (Pr < W between 0.62 and 0.91), the Breusch–Pagan test (Pr > chi2 between 0.46 and 0.78) and the Durbin–Watson test (D between 1.76 and 1.90) do not allow rejection of the respective null hypotheses, thus confirming the normality, homoscedasticity and no autocorrelation of residuals.

In general, selling price depends on both farming and non-farming categories of variables. In particular, all the farming variables have the expected signs for all cropping systems and in both study areas. Specifically, for Area A cereal fields, the sale of an additional hectare of land increases the selling price by 3%, the production of an additional tonne of wheat by 6%, and the location of the property along a highway by 10%. In contrast, each unit increase in the land slope and each additional kilometre between the property and the nearest urban centre generates depreciations of 2% and 0.5%, respectively. The same trends emerge for Area B, but the absolute values of the coefficients are higher, except for the variable related to the distance. In this case, orography in Area A is unfavourable and infrastructures are weaker, so that distance between urban centre and property is more affected by this variable in the extensive area. Hence, the economies of scale, the fertility and gradient of farmland, and the proximity to urban centres and infrastructures are more important in the intensive area, where higher yields and minimization of the production costs are crucial objectives. These relationships between predictors and selling price, as well as the differences between the study areas, are confirmed also for the other cropping systems. In addition, the findings highlight that, for each area, the incidence of these determinants is greater for the most intensive crops (grapes) than for the extensive ones (cereals). Overall, the coefficients of farming variables differ among the cropping systems and the study areas only in their magnitude, hence in the intensity of the relationship between predictors and selling price.

With regard to the environmental, historical and cultural determinants, the variations concern both the size of coefficients and the related signs. In Area A, the selling price of olive groves and vineyards increases by 2% and 4%, respectively, for each kilometre further away from a river. This is related to the higher risk of flooding near watercourses, which can seriously damage crops and related structures. On the contrary, the selling price for the same crops in Area B decreases by 2% with each kilometre further away, both for the possibility of drawing irrigation water directly from the river and for the presence of superficial aquifers that facilitate the drilling of new wells. This determinant, instead, is irrelevant for cereal fields, as cultivated without irrigation water.

The selling price increases from 1% to 4% in Area A and from 1% to 2% in Area B with each kilometre further from woodlands and protected natural areas. This is related to the considerable damage caused by wild animals (mainly wild boars) and wildfires to farmland near these natural

Table 4
OLS regression with correction for spatial autocorrelation in Area A.

Variable	Cereal fields			Olive groves			Vineyards		
	Coeff.		s.e.	Coeff.		s.e.	Coeff.		s.e.
Farming characteristics									
Size	0.0323	***	0.0058	0.0357	***	0.0088	0.0592	***	0.0095
Yield	0.0638	**	0.0267	–		–	–		–
Age	–		–	0.0032	***	0.0006	−0.0077	**	0.0031
Slope	−0.0210	**	0.0091	−0.0287	***	0.0054	−0.0385	***	0.0100
Distance	−0.0051	**	0.0022	−0.0084	**	0.0032	−0.0102	***	0.0027
Road	0.1037	*	0.0503	0.1166	**	0.0509	0.1318	***	0.0276
ES characteristics									
River	0.0106		0.0075	0.0197	**	0.0068	0.0385	***	0.0111
Woodland	0.0118	***	0.0027	0.0289	**	0.0127	0.0371	***	0.0105
Groundwater	0.0419		0.0407	0.0536		0.0466	0.0720	**	0.0273
Irrigation network	0.0733	**	0.0285	0.1215	**	0.0445	0.2163	***	0.0505
Scenic site	0.0055		0.0043	−0.0089	**	0.0032	−0.0166	**	0.0064
Historical site	−0.0063		0.0053	−0.0139	**	0.0058	−0.0211	***	0.0058
Building	0.0818	**	0.0347	0.1061	***	0.0247	0.1374	***	0.0320
Constant	5.3622	***	1.0392	6.3645	***	1.1614	5.8134	***	1.2343
Obs.	119			106			94		
Prob.>F	0.0000			0.0000			0.0000		
R-square	0.6363			0.6941			0.7738		
Adj. R-square	0.6026			0.6619			0.7465		

* Sign. 10%; ** Sign. 5%; *** Sign. 1%.

Table 5
OLS regression with correction for spatial autocorrelation in Area B.

Variable	Cereal fields			Olive groves			Vineyards		
	Coeff.		s.e.	Coeff.		s.e.	Coeff.		s.e.
Farming characteristics									
Size	0.0368	***	0.0057	0.0373	***	0.0067	0.0692	***	0.0104
Yield	0.0835	***	0.0248	–		–	–		–
Age	–		–	0.0043	***	0.0010	−0.0185	***	0.0031
Slope	−0.0314	**	0.0109	−0.0459	***	0.0070	−0.0631	***	0.0135
Distance	−0.0029	***	0.0006	−0.0036	**	0.0014	−0.0077	***	0.0017
Road	0.1321	***	0.0346	0.1655	***	0.0351	0.1964	***	0.0520
ES characteristics									
River	−0.0083		0.0059	−0.0175	**	0.0071	−0.0218	***	0.0045
Woodland	0.0082	***	0.0015	0.0095	**	0.0035	0.0164	***	0.0032
Groundwater	0.1235	**	0.0530	0.1763	***	0.0359	0.2457	***	0.0376
Irrigation network	0.0584		0.0420	0.1311		0.0986	0.1741	***	0.0414
Scenic site	0.0067		0.0057	0.0083		0.0075	0.0081		0.0180
Historical site	0.0056		0.0045	0.0049		0.0039	0.0192	***	0.0030
Building	0.0271		0.0343	−0.1013	**	0.0397	−0.1235	***	0.0165
Constant	5.3546	***	1.2540	5.4071	***	0.9453	6.5621	***	1.3558
Obs.	156			116			151		
Prob.>F	0.0000			0.0000			0.0000		
R-square	0.6934			0.7287			0.8020		
Adj. R-square	0.6723			0.7029			0.7879		

* Sign. 10%; ** Sign. 5%; *** Sign. 1%.

Table 6
OLS estimates according to Halvorsen and Palmquist (1980), per cropping system and area (only significant coefficients).

	Area A			Area B		
	Cereal fields	Olive groves	Vineyard	Cereal fields	Olive groves	Vineyard
Size	3.3%	3.6%	6.1%	3.7%	3.8%	7.2%
Yield	6.6%	–	–	8.7%	–	–
Age	–	0.3%	−0.8%	–	0.4%	−1.8%
Slope	−2.1%	−2.8%	−3.8%	−3.1%	−4.5%	−6.1%
Distance	−0.5%	−0.8%	−1.0%	−0.3%	−0.4%	−0.8%
Road	10.9%	12.4%	14.1%	14.1%	18.0%	21.7%
River		2.0%	3.9%		−1.7%	−2.2%
Woodland	1.2%	2.9%	3.8%	0.8%	1.0%	1.7%
Groundwater			7.5%	13.1%	19.3%	27.9%
Irrigation network	7.6%	12.9%	24.1%			19.0%
Scenic site		−0.9%	−1.6%			
Historical site		−1.4%	−2.1%			1.9%
Building	8.5%	11.2%	14.7%		−9.6%	−11.6%

elements.

With regard to the use of irrigation water, in extensively farmed and arid Area A, the use of groundwater from private wells is valued only by buyers and sellers of vineyards, and has a positive incidence of 7% on the selling price. In general, wells are not common in this area since are more expensive to construct due to the greater depth of the aquifer, and since entail higher maintenance costs for the hydrogeological instability. Irrigation via the public water network, instead, is easier, and this has a positive incidence between 7% and 22% on selling prices of all the considered cultivations. In contrast, private wells positively affect selling prices by 12%–25% in the Area B, whereas the public irrigation network interests only winegrowers (17%), who appear willing to pay for both types of irrigation to ensure more water to wine grapes, characterized by a larger demand of this resource.

In Area A, an increase in the distance from historical or archaeological sites and from scenic sites reduces selling prices of olive groves and vineyards by 1%–2% per kilometre. However, operators do not consider these determinants for cereal fields. In Area B, on the other hand, only the distance of historical or archaeological sites from vineyards is important, so that their selling price increases by 2% per kilometre. In general, the positive impact of these variables in Area A can be explained by the larger number of farms producing quality oil and wine with EU quality certifications, i.e. PDO/PGI, to which these sites award typicality. On the contrary, farmers in Area B recognize depreciation of vineyards in connection to the administrative and bureaucratic difficulties involved in obtaining permission to construct and manage a new *Tendone* system.

In Area A, the presence of a traditional rural building on a property increases the selling price for all three cultivations considered by 8%–14%. These buildings can be used as stores for agricultural machinery and equipment, as shelters for animals, as factories for on-farm production of quality products, or as homes. In contrast, these buildings do not affect the selling price of cereal fields in Area B, and depreciate the value of olive groves and vineyards by 10% and 12%, respectively. Indeed, farmers in Area B do not directly sell or transform their harvests and do not live in the countryside, thus they consider these structures a nuisance for their occupation of productive soil and for their interference with agricultural practices. However, landowners are forced to maintain these constructions, which are protected by regional laws.

Finally, the *t*-test for each interaction variable indicates significant differences between the areas for all the significant predictors (Table 7).

5. Discussion of results

The study investigates how heterogeneous types of determinants affect selling price of farmland, to vary of cropping system and farming intensity. This approach can be used to define economic schemes for farmland market, thus favouring farming practices apt to preserve environmental, historical and cultural components in the framework of suitable territorial policies (Petrillo and Sardaro, 2014).

In general, the results highlight that farming determinants generate the same trends for the considered cropping systems and in both areas, so that flat and fertile properties in the proximity of important infrastructures, and with a managerial configuration able to generate economies of scale, have a higher value. However, as farming intensity increases, the impact of these determinants rises in terms of the absolute value of the coefficients. Thus, the farmland market mainly rewards management based on a massive use of productive factors and inputs per unit area, which can boost productivity and consequently maximize

Table 7
Student's t-test concerning the differences in OLS coefficients between areas (Area A compared to Area B).

	Cereal fields		Olive groves		Vineyards	
Farming determinants						
Size	−2.36	**	−2.21	**	−2.53	**
Yield	−5.39	***	–		–	
Age	–		−2.74	**	−6.28	***
Slope	−4.19	***	−5.57	***	−5.76	***
Distance	3.84	***	6.08	***	2.41	**
Road	−3.70	***	−5.14	***	−3.92	***
ES determinants						
River			2.61	**	4.04	***
Woodland	3.27	***	7.84	***	5.23	***
Groundwater	−7.10	***	−7.22	***	−10.72	***
Irrigation network	4.39	***	−2.44	**	4.38	***
Scenic site			2.73	**	6.79	***
Historical site			6.31	***	2.24	**
Building	8.54	***	1.96	*	4.56	***

* Sign. 10%; ** Sign. 5%; *** Sign. 1%.

profits. On the other hand, the impact of environmental, historical and cultural determinants is more multifaceted. In particular, three land-market dynamics were detected: i) determinants positively capitalized in the selling price; ii) determinants negatively capitalized in the selling price; iii) determinants not capitalized at all. In the first market dynamic, determinants contribute to the management of production processes that have a lower impact on ecosystems and are based on the involvement of historical and cultural components, thereby contributing to diversification of production and providing higher incomes. However, in some cases, these determinants are positively capitalized, but in order to boost overexploitation of resources. On the other hand, negative capitalization occurs if the environmental, historical and cultural determinants hinder farming activities. Thus, the outcomes highlight different levels of capitalization of determinants in selling prices, which can be used to define adequate economic interventions in the farmland market to favour the preservation of the environmental, historical and cultural components of territory in the short, medium and long terms.

The farmland market in the extensive area A highlights the risk of flooding associated with rivers, since their proximity to properties depreciates land value. Indeed, flooding causes serious damage on the steep terrain of this area, and its narrower rivers create stronger water flows, with a greater damage to crops. This effect is significant on vineyards, due to the higher vulnerability of such cropping system. In contrast, in the intensive farming Area B, these natural elements are positively capitalized in the selling price, since allow the direct drawing of irrigation water, and facilitate the drilling of private wells for the presence of surface aquifers. In the intensive area farmers are willing to suffer rare flood damage in exchange for the constant and higher yields enabled by readily available irrigation water from rivers, which therefore mainly supply benefits derived from their direct use. However, these agricultural practices damage rivers and their associated flora and fauna, and increase the impacts from the leaching of nitrogenous fertilizers and pesticides, with consequent eutrophication (Richard et al., 2018). Therefore, study of the farmland market allows the identification of areas at greater risks from the presence of rivers, and in which decision makers can intervene with compensation or subsidy strategies to stimulate farmers in adopting cultivation practices that are more environmentally friendly.

Proximity to woodlands, wetlands, parks and natural reserves causes a general depreciation in the value of properties for each cropping system in both areas. However, this trend is more marked in the extensive Area A, where these natural components are more common. The main causes are related to the damage that wild animals and fires can generate to crops. In particular, wild boars (*Sus scrofa* Linnaeus, 1758) are very widespread in Area A and can eat the young branches of olive trees and vines, as well as the harvest (cereals, olives and grapes). They can also scrape the trunks of olive trees and vines, overturn young plants and trample the soil. However, this variable has the greatest incidence for vineyards in Area A, where grapes in the Espalier system are approximately 1 m above the ground, so that boars can easily eat young branches and grapes. In contrast, in the intensive *Tendone* system used in Area B, vegetation is approximately 1.70 m above the ground, i.e. out of the reach of wild boars, although their scraping and trampling can still do considerable damage. Nevertheless, at present, Apulia has no effective law concerning management strategies for wild boars in agricultural areas, although local farmers report increasing levels of crop damage. Therefore, an appropriate solution to this problem is urgently required (Parco Nazionale dell'Alta Murgia, 2016). With regard to fire risk, Apulia's low annual precipitations and medium-high temperatures, mainly in summer, favour fires, which are more frequent in Area A (Regione Puglia, 2018). Thus, more financial and operative inputs should be directed towards prevention and management of fires in the agricultural areas of the inland and hilly territories. This requires specific intervention plans based on management of forest undergrowth, creation of firebreaks, establishment of first aid forces, and planning of strategies to preserve crops (Sardaro et al., 2018). Thus, also in this case, the farmland market highlights a need for action to avoid negative impacts of natural components on farming and to foster positive capitalization of the value of woodlands, wetlands, parks and natural reserves in farmland selling prices.

The findings on the use of irrigation water highlight a greater preference in Area A for the public network, whereas private wells are positively capitalized in the selling prices in intensive Area B. Only in the case of vineyards, a certain importance is given to both sources of water in both areas, since grapes require greater quantities. In general, in Area A, the public network is a good substitute of private wells, which involve higher drilling and management costs, while groundwater is considered the most secure irrigation source in Area B owing to its greater flexibility in terms of both water quantity and frequency of irrigation. Indeed, the public network in the intensive area often limits the water supply for the need to serve a number of farmers at the same time and for the high irrigation cost. In addition, especially in dry years, the irrigation service is strongly reduced or even interrupted, thus jeopardizing farm production. These findings confirm the inability of the public irrigation network in Apulia to meet the regional water demand, since the water supply accounts for 31% of the water used and only 23% of the water required, i.e. 874 million m^3/year (Nino and Vanino, 2009). Foggia Province contains almost a third of the regional irrigated area (about 76, 000 ha), but the public irrigation network is often deactivated, or even absent (Fabiani, 2009). Thus, farmers prefer groundwater to the public irrigation network especially in the intensively farmed areas, with consequent overexploitation of the resource. The massive use of groundwater in Area B causes water scarcity and salinization of aquifers, which has negative impacts on soil and crops, and increases the risk of desertification (Richard et al., 2018; Shah et al., 2007; Fornés et al., 2005). The quality of water resources can be damaged for many decades, necessitating massive public and/or private investments to clean up contaminated sites. In order to solve these problems, according to the objectives of Water Framework Directive (2000/60/EC) (Griffiths, 2002; Lerner and Harris, 2009), the establishment of market instruments is desirable (Lopez-Gunn et al., 2011; Tsur, 2005; Alcon et al., 2014; MEA, 2003). In this connection, a groundwater pricing approach is an economically efficient option for enhancing the sustainable use of groundwater (Tuinstra and van Wensem, 2014; Turner et al., 2004), since farmers are expected to reduce water consumption after a price increase. However, the demand for groundwater is more inelastic in the case of the market oriented, high-value and highly productive crops grown in intensive farming areas (Dinar and Mody, 2004; Singh, 2016). Therefore, there is a need to implement appropriate measures in intensive areas to encourage the use of public irrigation networks and treated wastewater from residential and industrial areas (Carr et al., 2011), in addition to a pricing policy and to more efficient irrigation technologies, i.e. drip irrigation or irrigation techniques based on precision agriculture (Grant et al., 2007; Martín et al., 2007; Sardaro and La Sala, 2020). On the other hand, the public irrigation network requires specific interventions, namely: i) expansion and modernization; ii) control of water exploitation to reduce illegal use; iii) progressive closure of private farm wells; iv) creation of a technical assistance network to favour the reduction of irrigation water used, so as to increasing its efficiency. If jointly implemented, all these approaches can favour a sustainable capitalization of these natural resources in selling prices, and boost low-impact cultivation practices.

Proximity to historical, archaeological and scenic sites gives discordant results. In the extensive area (A), where typical quality products with PDO and PGI certifications are often made in private oil mills and wineries, these elements are positively capitalized in the selling price since contribute to the typicality of products (Giannoccaro et al., 2019), allow to intercept tourist flows, and facilitate sales. In contrast, in the intensive area (B) these components are not influential and can even depreciate farmland value. For example, national and regional laws preserve these sites by restricting the construction of *Tendone* systems nearby, for their aesthetic impacts, for the dangers connected with the excavation work required for their construction, and for the impacts from the agronomic practices (e.g. pest control and ploughing). Therefore, in order to contrast this trend, policy makers should promote more sustainable farming systems.

Finally, rural areas contain the historical evidence of peasant culture over the centuries, and this is considered a cultural asset to be preserved, as indicated by the European Landscape Convention (Council of Europe, 2000). Important elements of this cultural heritage are the traditional rural buildings which were used by farmers in the past as temporary or fixed homes, as storehouses for harvests and shelters for animals, etc. Nowadays, these buildings can be restored and used as summer homes, tourist facilities (farmhouses, museums of rural life, educational farms, etc.) or as production facilities for typical foods, thus becoming drivers of social and economic development. These components of rural cultural heritage have a historical, social, aesthetic, spiritual and educational value, and can provide a variety of public benefits, thus contributing to social welfare (Cucari et al., 2019). However, the farmland market in the intensive Area B does not reflect the real value the community attaches to these goods, or to the related services. Land sales mainly focus on productive aspects, while farmers consider these rural buildings a nuisance, and often neglect or abandon them. Therefore, there is a need for more adequate cultural preservation policies to protect these buildings in intensive farming areas (Choi et al., 2010). For example, management could be entrusted to entrepreneurs who would encourage their innovative use for activities with high social value, thus fostering the rural development of entire territories (Franco and Macdonald, 2018). This requires easier selling schemes for farmland including traditional rural buildings, or the constitution of joint ventures between landowners and tourist/cultural operators. This type of cooperation could allow the renovation and management of traditional rural buildings, encouraging their transformation into accommodation facilities, folk museums, and facilities for the production of typical products, etc. (Sardaro et al., 2017; Casieri et al., 2010; Deng et al., 2019).

Investigation of the effects of some territorial characteristics on the farmland market highlights that the capitalization of environmental, historical and cultural determinants in selling price can be positive, negative or null. It is worth noting that a positive capitalization does not necessarily mirror positive impacts of agriculture on territorial components. On the contrary, as this depends on farming intensity and crop, it could also indicate the presence of harmful dynamics boosted by intensive cultivation practices. This means that appropriate measures based on payments, subsidies or incentives should be introduced to trigger or strengthen good practices that favour the production of services for community or prevent them from being lost. Policies can favour farmers' acceptance of cultivation systems that provide public goods, but only if the private benefits are significant in comparison with the public benefits (Ma and Swinton, 2011).

The present study could be improved with regard to the quality of data and the econometric model used. Concerning data quality, some further characteristics of the environmental, historical and cultural elements could be considered. For example, the groundwater and public irrigation networks could have more specific characteristics that may affect selling price, i.e. quantitative and qualitative parameters of groundwater, managerial aspects of public networks, etc. In addition, the influence of historical buildings could also be related also to their dimensions, age, conditions, etc. However, collection of this type of information requires additional financial resources and time, although these could be reduced to a minimum if there were a public agency responsible for collecting and managing these land market data. With regard to the econometric model, more numerous and more available data would have allowed to integrate the OLS approach with more insightful models, namely quantile regression (Koenker, 2005), capable of investigating the influence of explanatory variables on the whole conditional distribution of the selling price and not only on its expected value.

6. Conclusions

Analysis of the land market can be extremely useful for decision-makers, since it can be used for designing measures aimed at preserving several types of resources spread across the rural territory. However, its feasibility is strictly related to the characteristics of the land market, in terms of transparency and frequency of sales. It is difficult to perform real estate analyses in Italy due to the lack of transparency of the farmland market and the small number of land sales per year (Sardaro et al., 2019; Acciani and Sardaro, 2014). Moreover, these analyses require multidisciplinary approaches concerning the relationship between farmland and territorial components.

The study makes it possible to gather knowledge on how territorial elements are capitalized in farmland selling prices. Among other aspects, policy makers should pay great attention to both positive and negative capitalization, which can pose dangers for the survival of environmental, historical and cultural elements. Therefore, there is a need for interventions in the farmland market to correct these market failures.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Ruggiero Sardaro: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Writing - review & editing, Supervision. **Piermichele La Sala:** Methodology, Investigation, Writing - original draft, Writing - review & editing. **Luigi Roselli:** Methodology, Investigation, Writing - original draft, Writing - review & editing.

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