AESTIMUM 78, Giugno 2021: 5-33

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Keywords: *Land market, Hedonic Pricing, Farmland appraisal*
Parole chiave: *Mercato fondiario, Prezzo Edonico, Stima fondi agricoli*
JEL codes: *C20*, *Q15*, *R00*

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Farmland value in the "Conegliano Valdobbiadene Prosecco Superiore PGDO" area. An application of the Hedonic Pricing method

In the last 30 years, numerous studies analysed the factors that affect land prices mainly using the Hedonic Pricing method. These studies have shown that many factors can affect land prices (e.g. land and surrounding territory characteristics, accessibility, proximity to urban area, etc.). However, they rarely addressed the analysis of the reliability of the models by comparing the estimated values to the observed one. Attempting to face this problem, our study analysed the land market of the "Conegliano Valdobbiadene Prosecco Superiore PGDO" area. Despite the quite high coefficient of determination (r^2 = 0.76) and statistical significance of the model parameters, we found that the percentage absolute deviation between observed and estimated value is higher than 30% in 34% of cases. Our results seem to suggest that future researches should devote particular attention to the analysis of the discrepancies existing between estimated values and market prices in order to support the appraisal activity of professional valuers.

1. Introduction

Farmland is a not negligible part of the Italian wealth. According to the Bank of Italy and ISTAT (2019) its value equals 294,347 million euro corresponding to about 2.73% of Italian wealth. Considering that such a figure is an underestimation of the farms' fixed capital because it does not consider the value of buildings, machinery and land improvements, it is possible to see that on the whole the agricultural assets also today play an important role in the Italian economy. This is of particular relevance if we consider that many times agricultural land is used to secure mortgage loans. A sound valuation is in this respect of particular relevance in order to prevent a financial crisis of the banking sector[1]. Hence the need to have valuation methods as reliable as possible and able to provide correct estimates of the agricultural land value.

At international level, in the last 30 years, numerous studies analysed the factors that affect land prices mainly using the Hedonic Pricing method (HP) (see for a

[1] "Lending institutions rely on sound valuations not simply for obvious reasons of commercial prudence in lending but also under the rules following the Basel III agreement governing their credit structures as applied to credit institutions in the EU by the Capital Requirements Directive 2013/36 and the Regulation (EU) 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms". (TEGOVA, 2016, p. 95)

DOI: 10.36253/aestim-10826

review De Noni et al., 2019; Perry and Robinson, 2001). The purposes of the investigations have been manifold. For example, numerous studies have tried to verify the effect of agricultural policy on land prices to understand whether the measures adopted can generate rent phenomena (Casini et al., 2015; Ciaian et al., 2010; Feichtinger and Salhofer, 2013; Kirwan, 2009; Latruffe and Le Mouël, 2009; Mela et al., 2012; Roberts et al. 2003). Another important field of investigation concerned the effects of territorial policy and urban growth on farmland prices (Abelairas-Etxebarria and Astorkiza, 2012; Delbecq et al., 2014; Géniaux et al., 2011; Guiling et al. 2009; Jaeger et al., 2012; Livanis et al., 2006; Plantinga et al., 2002). Especially in more recent years, many studies investigated the effect of various types of amenities on farmland prices also in order to measure their social value (Bastian et al., 2002; Borchers et al., 2014; Ma and Swinton, 2011; Sardaro et al., 2020; Uematsu et al., 2013; Wasson et al., 2013). Lastly, some scholars studied the effect of some intrinsic characteristics of agricultural land on their value (e.g. the availability of water, soil fertility, slope, shape of the plots, etc.) (Bastian et al., 2002; Drescher et al., 2016; Faux and Perry, 1999; Kostov, 2009; Maddison, 2009; Perry and Robison, 2001; Petrie and Taylor, 2007; Sundelin et al., 2015; Troncoso et al., 2010; Tsoodle et al., 2006; Xu et al., 1993).

In general, these studies have shown that there are many factors that can affect land prices, such as the intrinsic land characteristics, the characteristics of the territory where the agricultural land is located (e.g. proximity to urban areas, proximity to the road network, etc.), urban planning, presence of easements and proximity to various types of amenities (lakes, woods, rivers, etc.).

Regarding the intrinsic characteristics, numerous authors have pointed out that fertility (measured with various types of indexes) or productivity of soils have a positive effect on the price per unit of area (Bastian et al., 2002; Drescher et al., 2001; Faux and Perry, 1999; Kostov, 2009; Maddison, 2009; Sardaro et al., 2018b; Tsoodle et al., 2006; Troncoso et al., 2010; Xu et al., 1993; Perry and Robinson, 2001; Sardaro et al., 2021; Uematsu et al., 2013).

The presence of irrigation water and good drainage in general also increase the unit price (Bastian et al., 2002; Kostov, 2009; Ma and Swinton, 2011; Perry and Robison, 2001; Sardaro et al., 2020; Tsoodle et al., 2006) while slope has a negative effect (Erwin and Mill, 1985; Hilal et al., 2016; Ma and Swinton, 2011; Sardaro et al., 2020; Sardaro et al. , 2021).

As for the location of the farm and the characteristics of the territory surrounding it, many studies highlighted that distance from the road network (Drecher et al., 2001; Kostov, 2009; Sardaro et al., 2018b; Snyder et al., 2008; Tsoodle et al., 2006; Khalid, 2015; King and Schreiner, 2004; Ma and Swinton, 2011; Sardaro et al., 2020; Sardaro et al., 2021) and from major inhabited centers (Kostov, 2009; Maddison, 2009; Sardaro et al., 2018b; Snyder et al., 2008; Khalid, 2015; Sardaro et al., 2020; Sardaro et al., 2021) reduces the price per unit of area.

The researches that have analysed the effect of amenities on prices are not very numerous and their results are difficult to compare since they considered different types of amenities, sometimes using specific indicators for the investigated area. In this regard, of particular interest is the research carried out by Sardaro et al. (2020) who found that the effect of various types of amenities changes accord-

ing to the type of crop and the characteristics of the rural area (Rural area with specialised intensive agriculture; Rural area with development problems). Proximity to woods always reduces the price of land, but this effect is higher in Rural areas with specialized intensive agriculture and for vineyards. The distance from scenic sites and historical sites, on the other hand, reduces the price only in the case of olive groves and vineyards located in the Rural area with specialized intensive agriculture.

From an operational point of view, in some cases scholars have used values estimated by experts or by the farmers and not market prices (Boisvert et al., 1997; Borchers et al., 2014; Choumert and Phélinas, 2015; De Noni et al., 2019; Devadoss and Manchu, 2007; Drescher and McNamara, 1999; Lehn and Bahr, 2018; Maddison, 2000; Mela et al., 2012; Sills and Caviglia-Harris, 2009). As observed by some authors, the values derived by opinion survey tends to diverge from the market price and therefore its use cannot be considered correct for appraisal purposes (Bigelow et al., 2020; Ma and Swinton, 2012).

Moreover, these values often referred to large areas (e.g. provinces, counties or regions) that were very heterogeneous as regards the characteristics of the land and territory. In other cases, while referring to real prices, some characteristics of the farmland sold have been associated with information relating to a large area (e.g. municipality or county) (Drescher et al., 2011; Donoso et al., 2013; Gracia et al., 2007; Guiling et al., 2009; Khalid, 2015; Sklenicka et al., 2013; Uematsu et al., 2013).

Therefore many of these researches, while being useful to understand which factors affect land prices on a large-scale, have limited usefulness when the purpose of the analysis is to estimate the value of a specific plot or to understand the functioning of the land market at a local level. The effect of a given factor at provincial level can be completely different from that found in a given small territorial context since the land market often has a purely local connotation (Cotteleer et al., 2008).

Another problem neglected by previous researches is given by the fact that the statistical goodness of fit of a model is not in itself sufficient to guarantee its ability to correctly estimate market prices. Especially when the Ordinary Least Squares (OLS) method is used, a high coefficient of determination can actually be associated with consistent deviations between estimated and observed data. On the other hand, the standard error of the estimates provides a measure of the average deviation between estimated values and observed values only in the case of linear models, while this does not happen for example in the case of the semi-logarithmic models that have been used in most of the researches on the land market cited above. In this regard, it should be emphasised that only two researches to our knowledge has attempted to verify a posteriori the reliability of the HP method for the estimate of farmland values by comparing the estimated values with surveyed or market prices (Caggiati et al., 1982; Hilal et al., 2016).

As regards Italy, researches are much less numerous and market prices have only been used in a few studies (Sardaro et al., 2018a; Sardaro et al., 2018b; Sardaro et al., 2020; Sardaro et al., 2021; Tempesta and Thiene, 1997).

This research aims to verify whether it is possible to make sufficiently reliable estimates of market prices through HP. In this regard, the percentage deviation be-

tween observed and estimated values was analysed in the case of 85 sales of land located in five municipalities belonging to the Protected and Guaranteed Designation of Origin (PGDO) "Conegliano e Vadobbiadene Prosecco Superiore" (hereinafter Prosecco PGDO). It is a hilly area characterised by considerable environmental and landscape variability that affects both the crop mix and land prices. In much of the land sold, there are more crops and it is necessary to use multivariate analysis such as HP for the estimation.

Furthermore, in the territory under examination, the land market presents elements that are in some ways unique and still little explored by research. The growing international success of Prosecco wine has led to a significant increase in the land demand for viticulture, which has progressively extended from vineyards to areas occupied by wood, arable land or meadows. The price offered by buyers often does not refer to the crops actually cultivated but to the income that could be obtained from the conversion of these crops into vineyards. However, there are some limitations to the possibility of planting vineyards where other crops are currently cultivated.

As is well known, the common agricultural policy has imposed considerable restrictions on the planting of vineyards since the 1970s. With EEC Regulation 822/87 the possibility of transmitting planting rights to another winegrower was allowed. Until 2013 to plant a new vineyard it was necessary to have planting rights that could be purchased by other winemakers (Galletto, 2014). With Regulation (EU) no. 1308/2013 from 1 January 2016 a new scheme came into force that allows the planting of new vineyards within the maximum annual limit of 1% of the national vineyard area.

It is possible to suppose that the EU wine market organisation and Protected Designation of Origin can potentially modify the functioning of the land market by increasing the market power of the landowners. This is particularly true in the case of wines that have a relevant market success such as Prosecco. Furthermore, the procedures for granting planting rights can lead potential buyers to believe that in the future, an arable land or a forest can be converted into a vineyard and therefore the price paid will not correspond to that of these crops but to the price of the vineyard discounted to the actuality (hope price).

This study presents some elements of novelty compared to other land market analyses.

First of all, it is one of the few HP applications in Italy where real market prices have been used and that addressed the problem of estimating the value of land in which there are different crops, as often happens in hilly and mountain areas. It is also one of the few national and international studies that have concerned vineyard land market (Gracia et al., 2007; Sardaro et al., 2018a; Sardaro et al., 2018b; Sardaro et al., 2020; Sardaro et al., 2021).

Second, by analysing the difference between actual and predicted value we tried to verify whether HP can be considered a reliable method for estimating farmland value.

The paper is structured as follows. The study area is briefly described in section 2 and the methodology is illustrated in section 3. The results are reported in

section 4, before discussing the findings and drawing our conclusions in the last section (5).

2. The study area

The study area is the territory of the Prosecco PGDO that is located in the northern part of the province of Treviso (Figure 1) and has a total area of 21,460 ha. From an administrative point of view, 15 municipalities belong to it, albeit to varying degrees (Table 1).

Morphologically, the territory can be subdivided into two distinct landscape systems. There is a first system that is further north and is made up of hills located in an east - west direction with steep slopes and deep valleys. In this area, the cultivation of vineyards was made possible by the construction of narrow grassy terraces starting from the sixteenth century. It is therefore one of the oldest areas of diffusion of the vine in specialised cultivation in the Veneto Region. In these hills the main cultivation activities are conducted mainly by hand given the steep slope of the land with only partial use of agricultural machinery.

The second system is instead composed of hills whose ridges tend to have a north - south direction, where the slopes are less pronounced and which are therefore easier to cultivate. Until the 1960s the vine was cultivated in the traditional "piantata di viti" in which arable fields were bordered by rows of vines and mulberries.

Average annual rainfall varies from 1,100 mm in Conegliano to 1,250 mm in Valdobbiadene, ensuring sufficient water supply for the Glera vine (from which the grapes used to produce the Prosecco wine are obtained), which are sensitive to both stagnation and drought. The altitude is between 100 and 500 m above sea level.

The Prosecco PGDO territory presents a considerable variability that strongly influences the quality of the grapes and wines produced. In this regard, the small area

Figure 1. The study area.

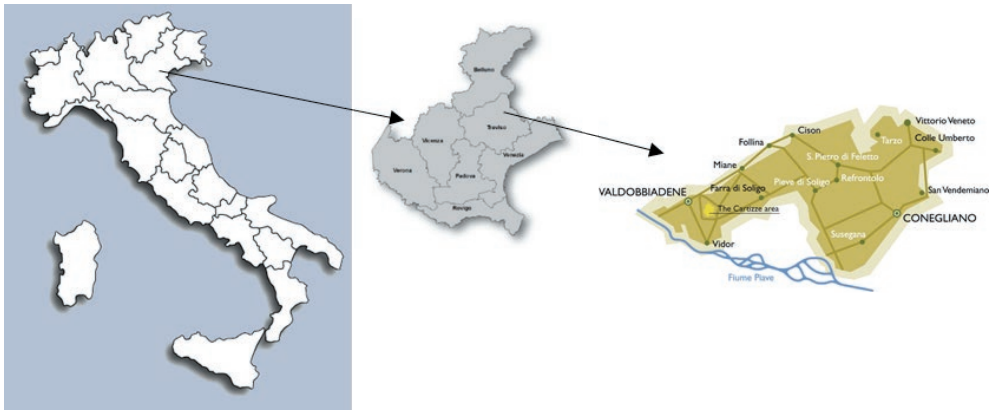

Table 1. Municipalities belonging to the "Conegliano Valdobbiadene Prosecco Superiore" PGDO.

Municipality	Municipal area	Surface belonging to the Prosecco PGDO	
		ha	%
Cison di Valmarino	2,880.04	578.98	20.1
Colle Umberto	1,360.42	333.77	24.5
Conegliano	3,636.14	3,052.60	84.0
Farra di Soligo	2,825.66	1,484.37	52.5
Follina	2,420.70	698.50	28.9
Miane	3,090.04	1,109.15	35.9
Pieve di Soligo	1,901.22	1,401.68	73.7
Refrontolo	1,304.69	1,303.74	99.9
San Pietro di Feletto	1,945.48	1,944.00	99.9
San Vendemmiano	1,843.13	166.50	9.0
Susegana	4,395.82	2,607.62	59.3
Tarzo	2,384.53	1,199.44	50.3
Valdobbiadene	6,086.27	2,699.41	44.4
Vidor	1,357.14	469.81	34.6
Vittorio Veneto	8,272.07	2,410.75	29.1
Total	45,703.35	2,1460.32	47.0

of Cartizze, which occupies 108 hectares in the municipality of Valdobbiadene, assumes particular importance. In it, due to the particular exposure and nature of the soils, a superior quality product is obtained, which has a considerably higher price than that obtained in the other parts of the Prosecco PGDO.

Indeed, in the 2020 harvest the average price of Cartizze grapes was 4.05 €/kg, compared to an average price of 1.25 €/kg for grapes produced in the other parts of the Prosecco PGDO.

The vine-growing area, which at the beginning of the 2000s amounted to about 4,000 hectares, has progressively increased, so much so that by 2018 it was 8,446 hectares. There are many reasons for this trend, but an important role has certainly been played by the growing success of Prosecco on national and international markets (Boattoet al., 2019). The strong demand for areas to be used for vineyard cultivation has meant that land has reached extremely high prices. According to the Crea-PB database[2], the price of vineyards in 2019 was around 35-50 €/m^2, while annual rents

[2] The cited data can be downloaded at the following website: https://www.crea.gov.it/web/politiche-e-bioeconomia/dettaglio-servizio/-/asset_publisher/PfOBDvsvmM6v/content/indagine-mercato-fondiario

Table 2. Distribution of the collected real estate transactions among the municipalities under investigation.

Municipality	N.	%
Colle Umberto	12	14.1
Conegliano	14	16.5
San Pietro di Feletto	14	16.5
Susegana	11	12.9
Valdobbiadene	31	36.5
Vittorio Veneto	3	3.5
Total	85	100

were between 4,000 and 7,000 €/ha in the Valdobbiadene area and between 3,500 and 6,000 €/ha in that of Conegliano.

3. Materials and Methods

3.1 Data collection

To analyse the land market, we collected 91 sales, which took place between 2008 and 2018. Land not classified as agricultural by the urban plan was excluded from the database. Furthermore, sales with unusually low prices compared to those of the area where they are located were excluded. Overall, the final sample is made up of 85 trades that took place in six municipalities of the Prosecco PGDO area that can be considered representative of the entire territory (Table 2).

Since sales are distributed over a rather long period, prices have been converted into constant prices using the GDP deflator provided by ISTAT to remove the effects of inflation.

The information reported in Table 3 has been extrapolated from the deeds of sale. This information is useful for knowing, in addition to surface area, price, degree of fragmentation and presence of buildings, also the presence of various factors that may limit the owner's property rights. These limitations may derive above all from environmental and urban planning restrictions which may constrain or preclude the transformation of the land into a building area or affect the possibility of changing the crop currently cultivated.

For example, in the presence of a forest restriction, the transformation of a forest into a vineyard becomes more difficult[3]. The presence of some easements that

[3] However, note that according to Article 5 of Legislative Decree 3 April 2018, no. 34 "Testo unico in materia di foreste e filiere forestali", cannot be considered woods: land registered in the "National Register of rural landscapes of historical interest, agricultural practices and tra-

Table 3. Data collected in the deeds of sale.

Date of the deed of sale
Cadastral map information (parcel and sheet number)
Surface
Price
Number of plots into which the sold land is divided
Pre-emption right
Buyer and seller information (person or company, *professional agricultural entrepreneur*; presence of kinship between the parties)
Presence of easement: right of way, gas pipeline, high-voltage overhead transmission line, water line.
Presence of rural building
Rented land
Hydrogeological, forestry and landscape restrictions indicated in the certificate of urban destination
Type of zone defined by the municipal general urban plan

could affect the type of cultivable crops (for example, methane pipeline or power line) may also be important.

Lastly, the importance of the characteristics of the parties who participated in the transaction should be recognised since, as pointed out by some authors (Cotteleer et al., 2008; Perry and Robinson, 2001), they can affect the agreed price.

However, the deed of sale does not contain information relating to many factors, both intrinsic and extrinsic, which can affect the price of agricultural land. To make up for this deficiency, the lands were first georeferenced using cadastral data. For this purpose, the WMS cadastral cartography based on the Web Map Service 1.3.0 standard, present in the Revenue Agency's Cadastral Cartographic Geo-portal, was consulted. This procedure allowed an integrated visualization with other territorial data and to interface the cadastral data with Google Earth. Through the use of placemarks, the precise location of the land on Google Earth and the geographical coordinates of its central point were identified.

Through Google Earth it was possible first of all to analyse the historical aerial images to learn the land use at the time of sale and the current one. Crops were divided into three classes: vineyards, herbaceous crops and woods. Given the quality of the images, it was not possible to distinguish with certainty the arable land from the meadows and therefore it was decided to group them into a sin-

ditional knowledge", established by the Ministry of Agricultural Food and Forestry that were cultivated in the past. In this regard, it should be noted that the northern part of Prosecco PGDO, which has an area of 10,802 ha, belongs to this Register.

Table 4. Shapefiles of the Geo-portal of the Veneto Region used in the study.

Road network
Level curves
Regional hydrographic network
Soil map
Soil permeability map
USDA Hydrologic Soil Group
Map of the texture and gravel within the first 50 cm of soil
Land use map
"Historical Centres" and "Minor Historical Centres" taken from the Atlas of the historical centres of the Veneto Region.
Sites of Community Importance and Special Protection Areas
Areas under hydrogeological restriction
Areas under forestry restriction
Areas under landscape restriction
Other land use restrictions (road, railways, etc.)
"First rank regional centres"; "Second rank intermediate urban centres"; "Third rank local urban centres"; "Local urban centres of the fourth rank" and "Local urban centres of the fifth rank"

gle class. This information also allowed us to see if after the sale the cultivations changed and in particular if woods and herbaceous crops had been transformed into vineyards. This information is of particular relevance in an area such as the one under investigation since it is very likely that buyers' willingness to pay is considerably influenced by the possibility of planting a vineyard in the future.

Secondly, it was possible to interface the data relating to the location of the sold land with those inferable from the shapefiles relating to various territorial themes available on the Geo-portal of the Veneto Region (Table 4). It was thus possible to know the geomorphological and agronomic characteristics of the land and their position with respect to the road network and urban and rural settlements.

Using the information in Tables 3 and 4, the variables reported in Tables 5 and 6 were calculated and then used to select the statistical model described in the following section.

3.2 The HP model

Since in only 61% of the real estate transactions surveyed the land consisted of a single crop and the territory in question has a high geomorphological and microclimatic variability, it is not possible to use a single-parameter procedure to estimate the value of the land (e.g. mean price). In this case, the only approach that

can be used is Hedonic Pricing (HP), which is based on the estimate of a function that relates the price (p) to the characteristics of the property (x_i):

$$p = \sum_{i=1}^{n} \beta_i \cdot x_i \quad (1)$$

The meaning of the coefficient β_i changes according to the mathematical model used in the estimate. In the case of the linear models β_i corresponds to the marginal price of any property's characteristics. In the case of semi-logarithmic models, which are the most used in the analysis of the land market, for continuous variables the coefficient β_i multiplied by 100 is equal to the percentage change in the price determined by a marginal variation of a given characteristic. For dummy variables, on the other hand, the following equation holds:

$$\text{Percentage price variation} = 100\,[\exp(\beta_i)-1] \quad (2)$$

It is interesting to note that in the case of dummy variables the exponential of the regression coefficient conceptually corresponds to the coefficient used in the estimation models for differentiation coefficients or for merit scales. In fact, in the case of semilogarithmic functions the model (1) can be rewritten as follows:

$$p = \prod_{i=1}^{n} e^{\beta_i x_i} \quad (3)$$

The use of HP for appraisal purposes poses operational and interpretative problems of some importance. First, you need to decide whether to use price or price per unit area as dependent variable. In the case of agricultural land in almost all of the publications analysed the price per unit area is used and to our knowledge, only three studies used the price (Hilal et al., 2016; Petrie and Taylor, 2007; Tempesta and Thiene, 1997).

The choice of one or the other alternative has advantages and disadvantages that must be considered by the researcher. The use of the price has the advantage of making the appraisal easier when the land sold is characterised by the presence of many of crops and rural buildings. In this case, using the surface areas of the various crops and buildings as independent variables it is possible to estimate the average and marginal price of each of them.

However, it becomes more complex to determine the relationship that exists between some intrinsic and extrinsic characteristics and the price. Consider, for example, the case of the distance of agricultural land from main roads that, at least theoretically, should be negatively correlated to the price. If a larger farmland was located at a greater distance from the road, the model could identify a positive relationship between distance and price. The close relationship that exists between price and surface area could obscure the effect of other potential factors that might play an important role in the formation of prices.

When the dependent variable is the price per unit of area (p_u), the analysis of the effect of intrinsic and extrinsic characteristics becomes simpler, but it becomes

more complex to take into account the presence of different crops and buildings in the model.

In some researches, the problem has been addressed by estimating separate models for each single crop (for example: arable land, vineyards, horticultural crops, etc.) (Borchers et al., 2014; Sardaro et al., 2018a; Sardaro et al., 2018b; Sardaro et al., 2020; Sardaro et al., 2021) or by inserting dummy variables relating to the type of crops present in the farmland or the presence of buildings (Gracia et al., 2007; Hilal et al., 2016). The first solution is feasible only if the sales refer to specialised farms. The second procedure is not very correct from the appraisal point of view, since the estimated value is independent of the area actually occupied by crops. However, it can be useful to take into account small marginal areas or buildings of modest size which have the same characteristics among all the farmland analysed.

In our study, to take into account the presence of different crops, the percentage of land occupied by each of them was included among the model parameters (King and Schreiner, 2004; Ma and Swinton, 2011; Snyder et al., 2008; Tsoodle et al., 2006; Xu et al., 1993). As regards the buildings, considering their type and their small size, it was preferred to use a dummy variable (Donoso et al., 2013; Elad et al., 1994; Petrie and Taylor, 2007).

Following the approach of numerous researches, a semilogarithmic model has been estimated in which the dependent variable is the logarithm of the price per square metre (Borchers et al., 2018; Drescher et al., 2001; Maddison, 2009; Sardaro et al., 2018a; Snyder et al., 2008).

The p_u of each crop was estimated by calculating the exponential of 100 β_i. However, it should be noted that if the percentage of all crops is entered in the model, it is not possible to enter the constant and this makes it difficult to establish the reliability of the model since the coefficient of determination is not comparable with that of the models in which there is the constant. To overcome the problem Hoking (1996, p. 178) suggests estimating a regression between observed and estimated values and considering the coefficient of determination thus obtained as a measure of the goodness of fit of the model. In fact, according to Eisenhauer (2003 p. 80) "this measure is equal to the unadjusted coefficient of determination for the OLS model".

For purely comparative purposes, a linear model was also estimated in which the dependent variable is the price, which, however, as will be seen, does not contain information useful for understanding the factors that influence the selling price.

Two other problems arise in the use of HP that must be addressed by the valuers. First, you have to choose which independent variables to include in the model. In this regard, in the researches that used very large samples relating to large areas, all the characteristics that at least theoretically could affect the price, regardless of their statistical significance, were generally included in the models. This approach has the advantage of allowing you to see directly what are the factors that market operators actually consider when buying land and which ones play a marginal role in their choices.

Having small samples, as often happens when appraising farmland, it is in some ways more correct to use procedures that allow you to select the independent variables that are statistically significant. Furthermore, in the case in which the models are to be used for appraisal purposes, the presence of non-significant variables is substantially useless and, in general, parsimonious models are preferable with regard to the number of parameters.

In this study, the parameters were selected with a mixed procedure. Initially, through a stepwise regression, the variables best correlated to the p_u were selected from those reported in Table 5. Subsequently, considering the limits of stepwise regression[4], the variables selected by the statistical program at each step were analysed. Lastly, a regression function was estimated by means of the OLS method in which the statistically significant covariates of greatest estimative interest were inserted.

To estimate an HP model, various statistical approaches can be used, but from the valuer's point of view it becomes essential to have criteria that allow its reliability to be verified. As is known, to establish the statistical goodness of a model estimated with the OLS method, various statistical indices are used such as the standard error of the estimate, the coefficient of determination, Fisher's F and the statistical significance of the regression coefficients. Generally speaking, it can be said that a regression model provides estimates that are all the more reliable the lower the standard error and the higher the other indices.

From a professional valuer's point of view, for a model to be reliable, the deviation between estimated and actual values must be as low as possible and none of the mentioned indexes provide a direct and easily interpretable measure of the error that can be committed using the model for the estimation of real estate values.

In this regard, the analysis of residues is certainly more useful, as it allows you to verify how much the estimated values differ from the real ones and to calculate the average percentage deviation between them. In fact, it can easily be verified that for models that have a satisfactory coefficient of determination (for example higher than 0.70-0.80) the percentage deviation can be very high. Considering that, since the error committed in the estimate is similar whether the estimated value is higher or lower than the one observed, it is useful to calculate the percentage deviation in absolute value both in monetary and percentage terms.

In analysing the results, the following indices will therefore also be used:

$$\textit{Mean Absolute Deviation} = \frac{1}{n} \sum_{i=1}^{n} \left| \, p_{ui\ observed} - p_{ui\ estimated} \, \right| \tag{4}$$

$$\textit{Mean Percentage Absolute Deviation} = \frac{1}{n} \sum_{i=1}^{n} \frac{\left| \, p_{ui\ observed} - p_{ui\ estimated} \, \right|}{p_{ui\ observed}} \tag{5}$$

[4] As stated by Whittingham et al. (2006, p. 1183) the principal drawbacks of stepwise multiple regression include "bias in parameter estimation, inconsistencies among model selection algorithms, and an inappropriate focus or reliance on a single best model, where data are often inadequate to justify such confidence".

Table 5. Selling price and intrinsic characteristics of the farmland.

Variables	Unit of measure/type of variable	Mean	Min	Max	St. Dev.
Surface	m^2	11,173	360	190,628	22,846
Price	euro 2018	314,852	4,368	5,560,500	762,902
Price per square metre	euro 2018	28.71	3.89	159.06	27.56
Land use at the selling date:					
- Cartizze	m^2	366.08	0	28,596.57	3,104.65
- Other vineyards	m^2	6,061.00	0	156,314.96	18,618.90
- Herbaceous crop	m^2	3,185.46	0	50,496.00	6,744.33
- Wood	m^2	1,560.28	0	25,000.00	4,146.74
Land use in 2018:					
- Herbaceous crop	m^2	959.01	0	22,580.00	3,032.12
- Wood	m^2	1,317.14	0	25,000.00	4,054.20
- Herbaceous crops and woods transformed into vineyards after the sale	m^2	2,469.60	0	50,496.00	6,361.37
Land use in 2018 - percentage:					
- Cartizze	Land %	3.49	0	100	18.38
- Other vineyards	Land %	41.45	0	100	43.82
- Herbaceous crop	Land %	15.02	0	100	33.26
- Wood	Land %	11.31	0	100	26.55
- Herbaceous crops and woods transformed into vineyards after the sale	Land %	28.73	0	100	40.33
Plot shape	Dummy variable	0.31	0	1	0.464
Land shared in two or more plots	Dummy variable	0.07	0	1	0.258
Altitude	m above the sea level	168.25	68	350	79.447
Slope	%	14.08	1	70	16.84
Soil texture:					
- Loam	Dummy variable	0.64	0	1	0.484
- Clay loam	Dummy variable	0.36	0	1	0.484
Gravel within the first 50 cm of soil:					
- Scarce	Dummy variable	0.33	0	1	0.473
- Common	Dummy variable	0.18	0	1	0.383
- Frequent	Dummy variable	0.14	0	1	0.350
- Abundant	Dummy variable	0.29	0	1	0.458
- Very abundant	Dummy variable	0.06	0	1	0.237

Variables	Unit of measure/type of variable	Mean	Min	Max	St. Dev.
Permeability:					
- low	Dummy variable	0.39	0	1	0.490
- moderately low	Dummy variable	0.22	0	1	0.419
- moderately high	Dummy variable	0.39	0	1	0.490
Potential runoff:					
- moderately low	Dummy variable	0.15	0	1	0.362
- moderately high	Dummy variable	0.31	0	1	0.464
- High	Dummy variable	0.54	0	1	0.501
Small farm building	Dummy variable	0.07	0	1	0.258

4. Results

4.1 Sold land characteristics

Tables 5 and 6 summarize the characteristics of the independent variables considered to estimate the HP model. The average area of the land sold is 3.11 ha with considerably variable values ranging from 360 m^2 to 19 ha. However, it should be noted that in 75% of cases the areas sold were less than 1 ha and half of the sales concerned land of less than 0.5 ha.

The average price of land is 314,800 €, but also in this case there is a considerable variability (minimum price = 4,368; maximum price = 5,560,500). Due to the great diversity of crop prices, the variability is much greater than that of the surface area.

As can be seen in Table 7, vineyards accounted for about 57% of the cultivated areas at the time of sale. In the following years, however, 18.79 ha of herbaceous crops and 2.07 ha of wood were planted with vineyards, so that by 2018 almost 80% of the area was planted with vines. Among the vineyards, there are also 3.28 ha of Cartizze that, as will be seen, has very high land values.

The average p_u is 28.71 €/m^2 with a minimum amount of 3.89 €/m^2 found in a wood and a maximum amount of 159.06 €/m^2 at which a plot of Cartizze has been sold.

The analysis of the average prices of land in which there was only one crop can give a first overview of the land values in the area under investigation. As regards the Cartizze in the three plots surveyed, the average p_u was 145.1 €/m^2. In the other vineyards the p_u is considerably lower (41.7 €/m^2) and presents a considerable variability (95% confidence interval (CI); 30.2 €/m^2 ÷ 53.1 €/m^2; N = 19).

Herbaceous crops have an average p_u of 15.6 €/m^2 (95% CI; 12.9 €/m^2 ÷ 17.5 €/m^2; N = 25). This is certainly a very high amount given that in the plain areas of the province of Treviso, according to the CREA-PB land values database, the price per square metre of arable land in 2018 was equal to 7.92 € and in hilly areas 5.91 €.

Table 6 Extrinsic characteristics of the farmland and information about buyers and sellers.

Variables	Unit of measure/ type of variable	Mean	Min	Max	St. Dev.
Municipality where the land is located:					
- Colle Umberto	Dummy variable	0.14	0	1	0.350
- Conegliano	Dummy variable	0.16	0	1	0.373
- San Pietro di Feletto	Dummy variable	0.16	0	1	0.373
- Susegana	Dummy variable	0.13	0	1	0.338
- Valdobbiadene	Dummy variable	0.36	0	1	0.484
- Vittorio Veneto	Dummy variable	0.04	0	1	0.186
Distance from the nearest asphalt road	m	129.39	0	1000	191.91
Distance from the nearest provincial or state road	m	1,941.35	0	7000	1,874.72
Distance from waterways	m	160.47	0	800	197.00
Distance from built-up areas	m	957.88	0	4000	714.71
Distance from urban centres	m	4,355.88	400	9000	2,135.77
Land use restrictions:					
- hydrogeological	Dummy variable	0.36	0	1	0.484
- Landscape	Dummy variable	0.52	0	1	0.503
- Forestry	Dummy variable	0.33	0	1	0.474
- Road	Dummy variable	0.35	0	1	0.481
- Railway	Dummy variable	0.01	0	1	0.108
- Gas pipeline	Dummy variable	0.05	0	1	0.213
- Ecological corridor	Dummy variable	0.08	0	1	0.277
- Cemetery	Dummy variable	0.04	0	1	0.186
Easement:					
- None	Dummy variable	0.51	0	1	0.503
- Right of way	Dummy variable	0.40	0	1	0.493
- Gas pipeline	Dummy variable	0.06	0	1	0.237
- Water line	Dummy variable	0.06	0	1	0.237
- High-voltage overhead transmission line	Dummy variable	0.02	0	1	0.152
Pre-emption right	Dummy variable	0.01	0	1	0.11
Buyer: company	Dummy variable	0.26	0	1	0.44
Buyer: Professional Agricultural Entrepreneur	Dummy variable	0.64	0	1	0.48
Buyer: relative of the seller	Dummy variable	0.11	0	1	0.31

Table 7 Crops surface area at the date of the transaction and in 2018.

Surface area at the date of transaction

	ha	%
Cartizze	3.11	3.28
Other vineyards	51.65	54.39
Herbaceous crops	26.94	28.37
Wood	13.26	13.96
Total	94.97	100.00

Surface area in 2018

	ha	%
Cartizze	3.11	3.28
Other vineyards	72.51	76.35
Herbaceous crops	8.15	8.58
Wood	11.20	11.79
Total	94.97	100.00

Surface area change

	ha	var %
Cartizze	0	0.00
Other vineyards	20.86	40.39
Herbaceous crops	-18.79	-69.75
Wood	-2.07	-15.58

These values can only be explained by the strong expectations of vineyard planting which can make it possible to considerably increase the land rent. This is all the more true in the case of the woods for which in the five sales where there were no other crops on average a price of 17.2 €/m^2 was paid and in two cases price exceeded 20 €/m^2.

Generally, the land sold consists of a single plot (93%) with an irregular shape (69%); they are located at an altitude between 68 and 350 metres above sea level (Table 5). The average slope is 14% and varies from 1% to 70%. On 19% of the land sold, the slope is higher than 20% and vine cultivation involves very high costs since most of the activities cannot be mechanized.

With reference to the other intrinsic characteristics, the soils have a loam or clay loam texture, about 34% of the cases have a high presence of gravel, while the permeability is rather variable. Probably due to the high slope, the soils have high (54%) or moderately high (31%) potential runoff.

In six of the transactions there were farm tool sheds. These buildings, especially in the past, were used to leave some of the equipment used to cultivate the

land on the fields. Currently they are often abandoned and, due to their architectural characteristics and location, cannot be used for other purposes.

Turning to the extrinsic characteristics, the average distance from the nearest asphalt road is 129 m and 45% of the land sold faces a road. However, land located far from the easier access roads is quite frequent: in 20% of cases it is in fact necessary to travel over 200 m of dirt road to reach asphalt roads, a situation that in hilly areas can make access to the land difficult, especially on rainy days. The distance of the provincial and state roads is much greater, being on average 1941 m.

Since in the territory in question, as in general in the whole Veneto Region, there are numerous small urban centres, from the surveyed land it is possible to reach them by covering less than 1 km on average and the maximum distance is about 4 km. The distance from urban centres (Conegliano, Vittorio Veneto and Valdobbiadene) is also quite limited (on average 4.3 km). In general, therefore, all land sold is in a fairly favourable position with respect to the presence of urban services.

As regards the presence of land use constraints, landscape (52%), hydrogeological (36%), road (35%) and forest (33%) constraints are particularly widespread. In 51% of cases the land sold is not burdened by easements of any kind while there is a right of way on 40%. Finally, as regards the characteristics of the subjects involved in the transaction, in 26% the buyer was a company, and in 11% the parties were relatives. Only one buyer used the pre-emption right to purchase the land.

4.2 The HP models

Table 8 shows the model in which the dependent variable is price. In this case, we have estimated a linear model as it has a better goodness of fit than other

Table 8. The price model.

Dependent variable: price (euro 2018)

Variables	B	Standard error	95.0% Confidence interval		VIF
			Inf.	Sup.	
Constant	7,007.94	9,627.38	-12,158.70	26,174.58	
Cartizze area at the selling date	135.70***	2.31	131.09	140.31	1.05
Other vineyards area at the selling date	32.29***	0.74	30.80	33.77	3.91
Herbaceous crop area at the selling date	12.23***	0.99	10.25	14.20	1.02
Wood area at the selling date	12.12***	4.21	3.74	20.50	3.83
Buyer; company	39,031.62**	17,421.19	4,348.70	73,714.55	1.20
Buyer and seller relatives	-54,992.95**	23,598.92	-101,974.79	-8,011.11	1.09

Note: *** significance 99%;** significance 95%. N = 85; adjusted r squared = 0.993; standard error of estimation = 64186.4; F = 1964.7 ($p<0.001$); Breusch - Pagan test = 26.75 ($p=0.0004$).

mathematical models. The determination coefficient is 0.993. However, note that the model is heteroskedastic (Breusch - Pagan test = 26.75; p = 0.0004). Multicollinearity problems are substantially absent (parameters VIF <5). Six independent variables were selected through stepwise regression: the area of Cartizze, other vineyards, herbaceous crops and woods at the date of sale, and two variables relating to the characteristics of the subjects who participated in the sale (company buyer; transaction between relatives).

In the model there are no variables related to the intrinsic or extrinsic characteristics of the properties sold since they do not have a statistically significant relationship with the price.

The coefficients of the selected variables are statistically significant with 95% probability, while the constant is not significant. As noted above, the regression coefficients of the cultivated areas correspond to their marginal price, while the p_u tends to decrease as the area increases. With reference to the minimum, maximum and mean values of the surface areas sold, the following p_u can be estimated:

	Area		
	min	max	mean
Cartizze	142.6	135.9	136.4
Other vineyards	46.5	32.3	32.9
Herbaceous crop	47.3	12.3	13.4
Wood	43.8	12.4	14.1

The confidence interval of the coefficients is quite low for vineyards and herbaceous crops and is instead very broad for woods whose marginal price with 95% probability is between 4.71 and 20.50 €/m^2. As mentioned, there are also two variables in the model relating to the subjects who participated in the sale. When the buyer is a company, the price is higher on average, while in the case of sales between relatives the price is considerably lower than when non-related parties are involved in the transaction. Also in this case the confidence interval is very wide. It can be deduced that the companies are interested in the purchase of higher-priced funds while exchanges between relatives involve funds with a lower price.

As for the appraisal reliability of the model, although the model explains more than 99.3% of the price variability, it has very high margins of error in estimates. The standard error of the estimate is 64,186 € (20.4% of the mean price), while the Mean Absolute Deviation is 43,110 € (13.7% of the mean price). Considering the Mean Percentage Absolute Deviation, it can be seen that on average the estimated values differ from the real ones by 58.3%. Only in 35% of sales the margin of error of the estimated values is less than 20% while in 22.4% of cases it is greater than 70% (Table 9).

The p_u model is more complex than the previous one (Table 10). Through the stepwise regression, 12 independent variables were selected concerning the intrinsic characteristics (percentage of land occupied by each crop, land divided into several

Table 9. Distribution of sales by class of percentage absolute deviation between estimated value and real value in the case of the price model (Table 8).

Percentage absolute deviation	N	%
lower than 5%	14	16.5
from 5 to 9.9%	5	5.9
from 10 to 14.9%	3	3.5
from 15 to 19.9%	8	9.4
from 20 to 24.9%	5	5.9
from 25 to 29.9%	12	14.1
from 30 to 34.9%	5	5.9
from 35 to 39.9%	3	3.5
from 40 to 49.9%	5	5.9
from 50 to 59.9%	3	3.5
from 60 to 69.9%	3	3.5
higher or equal to 70%	19	22.4
Total	85	100.0

Note: Mean Percentage Absolute Deviation = 58.43.

plots and slope), extrinsic characteristics (distance from an asphalt road, municipality where the land is located) and a feature relating to the parties involved in the transaction (land purchased by a company). The model has a coefficient of determination equal to 0.76, that can be considered satisfactory given the results of other researches, and does not present heteroskedasticity problems (Breusch - Pagan test = 13.82; p = 0.2420). Multicollinearity problems are also absent in this model.

The regression coefficients are significant with 99% probability, with the exception of the variables: slope, company buyer and municipality of Colle Umberto where the significance is 95%. Using the model, it is possible to estimate the p_u of the crops and the effect exerted on this amount by the other independent variables. As regards the first aspect, it is possible to estimate the following values:

	Mean value	95% confidence interval	
		inf	sup
Cartizze	203.6	124.0	334.2
Other vineyards at the sale date	36.1	29.1	44.7
Herbaceous crop in 2018	15.8	12.4	20.1
Wood in 2018	16.3	10.5	25.3
Herbaceous crops and woods transformed into vineyards after the sale	21.1	17.0	26.0

Table 10. Price per square metre model.

Dependent variable: p_u logarithm

Variables	B	Standard error	95.0% Confidence interval		VIF
			inf	sup	
% Cartizze area at the selling date	0.0532***	0.0025	0.0482	0.0581	1.381
% Other vineyards area at the selling date	0.0359***	0.0011	0.0337	0.0380	2.816
% Herbaceous crop area in 2018	0.0276***	0.0012	0.0252	0.0300	1.361
% Wood area in 2018	0.0279***	0.0022	0.0235	0.0323	2.240
% Herbaceous crops and woods area transformed into vineyards after the sale	0.0305***	0.0011	0.0284	0.0326	1.685
Buyer: company	0.2131**	0.1008	0.0123	0.4139	1.697
Land shared in two or more plots	-0.3763**	0.1621	-0.6994	-0.0532	1.198
Distance from nearest asphalt road	-0.0006***	0.0002	-0.0011	-0.0002	1.656
Slope	-0.0120***	0.0031	-0.0183	-0.0058	3.017
Colle Umberto	-0.3313**	0.1290	-0.5885	-0.0742	1.518
Vittorio Veneto	-0.7949***	0.2274	-1.2481	-0.3417	1.178
Valdobbiadene	0.3062***	0.1081	0.0908	0.5216	2.484

Note: *** significance 99%; ** significance 95%; N = 85; r squared = 0.760; standard error of estimation = 0.3122; F = 531.9 ($p<0.01$); Breusch - Pagan test = 13.82 ($p = 0.2420$).

In considering these values, however, it should be noted that they refer to flat land bordering an asphalt road sold as a single unit, located in the municipalities of Conegliano, San Pietro di Feletto and Susegana, where the buyer is not a company. However, the values are similar to those estimated with the previous model or calculated with the average of the sales prices in which the land sold was cultivated with a single crop.

The confidence interval of the average values is very broad for practically all crops. It is also interesting to note that, at least basically, the land that at the time of the sale was cultivated with herbaceous or forest crops and subsequently transformed into vineyards has a higher value than those in which the land use has not changed.

As regards the effect of the covariates, it can be seen first of all that if the sold land is divided into several separate plots, its price drops by 31%. The territorial location of the land is also important; in the municipalities located further east the prices are considerably lower (Vittorio Veneto -54.8%; Colle Umberto -28.2%) while in the municipality of Valdobbiadene, which is perhaps the most renowned production area of Prosecco PGDO, the land is worth an average of 35.8% more, even excluding the Cartizze that can only be grown in this municipality.

The abacus reported in Table 11 was constructed to understand the effect of distance from an asphalt road and slope. It can be deduced that, for example, the

Table 11. Percentage reduction of the price per square metre caused by distance from an asphalt road and slope.

Distance from asphalt road (m)	Slope (%)							
	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00
0	0.00	-11.35	-21.41	-30.34	-38.24	-45.25	-51.47	-56.98
100	-6.10	-16.76	-26.21	-34.59	-42.01	-48.59	-54.43	-59.60
200	-11.83	-21.84	-30.71	-38.58	-45.55	-51.73	-57.21	-62.07
300	-17.21	-26.61	-34.94	-42.32	-48.87	-54.68	-59.82	-64.38
400	-22.26	-31.09	-38.91	-45.84	-51.99	-57.44	-62.27	-66.56
500	-27.00	-35.29	-42.64	-49.15	-54.92	-60.04	-64.57	-68.60
600	-31.46	-39.24	-46.14	-52.25	-57.67	-62.48	-66.74	-70.51
700	-35.64	-42.95	-49.42	-55.16	-60.25	-64.77	-68.77	-72.31
800	-39.57	-46.43	-52.51	-57.90	-62.68	-66.92	-70.67	-74.00
900	-43.25	-49.70	-55.41	-60.47	-64.96	-68.93	-72.46	-75.59
1000	-46.72	-52.77	-58.13	-62.88	-67.09	-70.83	-74.14	-77.08

p_u of a land with a slope of 30% with direct access to an asphalt road is reduced by 30%. The p_u of a flat land located 300 m from the nearest asphalt road is reduced by 17%. It is also possible to see the combined effect of these two characteristics. The p_u of land with a 30% slope and located 300 m from an asphalt road is reduced by 42%.

Finally, the model highlights that if the land was purchased by a company, the p_u was 24% higher.

As noted, the coefficient of determination can be considered quite high for this kind of model. The Mean Absolute Deviation between observed and estimated values is 7.75 € (26.9% of the average p_u) while the Mean Percentage Absolute Deviation is 27.9%. The margin of error of the model is therefore far from negligible: in 56.8% of cases it is less than 20% and in 8.2% it is above 70% (Table 12).

5. Discussion and conclusions

The results of the study are partially consistent with what emerged in the national and international literature. The negative effect of slope on land value has also been found in other researches (Erwin and Mill, 1985; Hilal et al., 2016; Ma and Swinton, 2011; Sardaro et al., 2020; Sardaro et al., 2021). Compared to these studies, however, the effect of slope on the price is much less. This is probably due to the fact that in the area under investigation, land with a high slope is much more widespread and the cultivation systems have long been adapted to the geo-

Table 12. Distribution of sales by class of percentage absolute deviation between estimated value and real value in the case of the price per square metre model (Table 10).

Percentage absolute deviation	N	%
lower than 5%	7	8.2
from 5 to 9.9%	17	20.0
from 10 to 14.9%	7	8.2
from 15 to 19.9%	10	11.8
from 20 to 24.9%	7	8.2
from 25 to 29.9%	8	9.4
from 30 to 34.9%	8	9.4
from 35 to 39.9%	6	7.1
from 40 to 49.9%	5	5.9
from 50 to 59.9%	2	2.4
from 60 to 69.9%	1	1.2
higher or equal to 70%	7	8.2
Total	85	100.0

Note: Mean Percentage Absolute Deviation = 27.95.

morphological characteristics of the territory. It also has to be considered that the slope modifies the microclimate and can positively influence grape quality.

The negative effect of distance from the road network has also been highlighted in numerous studies, although the methods adopted to analyse it have been different. The results are therefore only partially comparable with those of our study. To analyse the effect of land accessibility many authors used a dummy variable relating to whether the land was adjacent to a road or not (Drecher et al., 2001; Kostov, 2009; Sardaro et al., 2018a; Sardaro et al., 2018b; Snyder et al., 2008; Tsoodle et al., 2006; Khalid, 2015; King and Schreiner, 2004; Ma and Swinton, 2011; Sardaro et al., 2020; Sardaro et al., 2021). In general, it emerged that land adjacent to roads has a higher value even if the type of road considered in the various studies is different (motorways, provincial or state roads or paved roads). Only in one other case, to our knowledge, was the distance between the land and road network measured. Troncoso et al. (2010) found a negative relationship between price and distance from the nearest paved road. However, note that in our study a negative relationship emerged only with regard to access to asphalt roads, while the distance from state and provincial roads was not included in the model since it is not statistically significant.

This difference is probably due to the fact that the Prosecco PGDO area has a high specialization and only the costs to access the land starting from the farmstead to carry out cultivation activities and those necessary to transport the grapes to the cellars can affect the viticulture profitability. From this point of view,

it should be remembered that, as in the whole of the Veneto Region hills, in the study area there is a scattered settlement structure and the farmstead is generally located near the farmland. In addition, the cellars that process the grapes are mainly located within the Prosecco PGDO area and it is therefore not necessary to travel long distances to transport the grapes from the vineyards.

Only one other study analysed the effect of fragmentation of the property and its shape, highlighting that the p_u drops if the land sold is divided into several separate plots and if the shape is not regular (Sundelin et al., 2015). The results of our study seem to confirm that fragmentation reduces the price while the shape does not have a significant effect probably because in the case of small plots its role is less important. The effect of fragmentation on the price may be due to the increase in the costs necessary to reach the farmland to carry out cultivation activities.

It is interesting to point out that some intrinsic and extrinsic characteristics, unlike other studies, were not found to be significantly correlated with the p_u. This happens, for example, in the case of the distance from major inhabited centres which, according to some authors, reduces the p_u (Kostov, 2009; Maddison, 2009; Sardaro et al., 2018a; Sardaro et al., 2018b; Snyder et al., 2008; Khalid, 2015; Sardaro et al., 2020; Sardaro et al., 2021). However, in all those studies the maximum distance from built-up areas was much greater than that found in the land sales analysed, which is 4 km for built-up areas and 9 km for urban centres.

It should also be considered that in an area with a strong product specialization and in which the cultivation profitability is very high, as in the Prosecco PGDO area, there is little interest in buying land with the hope of achieving a significant capital gain following their inclusion in a residential or industrial zone by the urban plan.

A second characteristic that has often been investigated in previous research is the size of the land sold, which in our investigation is not related to the unit price. In this regard, it should be noted that the results reported in the literature are not univocal. With one exception (Perry and Robison, 2001), all research conducted abroad identified a negative relationship between unit price and surface area sold (King and Schreiner, 2004; Kostov, 2009; Maddison, 2009; Ma and Swinton, 2011; Snyder et al., 2008; Roos, 1996; Troncoso et al., 2010; Tsoodle et al., 2006). On the contrary, a positive relationship was identified in four studies conducted in Italy (Sardaro et al., 2018a; Sardaro et al., 2018b; Sardaro et al., 2020; Sardaro et al., 2021).

A possible explanation for this discrepancy is the diversity of the surface areas involved in transactions that tend to be bigger abroad than those in the Italian studies. It can be assumed that in the case of small-sized land, as the surface area increases, the profitability of farming increases due to the effect of economies of scale. Conversely, in the case of very large properties, due to the small number of potential buyers, unit prices tend to decrease. The relationship between unit price and land area could therefore have a parabolic trend and an inverted U shape.

The model highlights that, all other factors being equal, the price of land differs considerably within the Prosecco PGDO area. It is interesting to note that this territorial variability essentially reflects the diffusion of specialised viticulture at the date of the agricultural census of 1929. In the municipality of Valdobbiadene

there were 582 ha of specialised vineyards, while in Vittorio Veneto there were only 7 ha and 2 ha in Colle Umberto.

As we noted above, while in the western part of the Prosecco PGDO area, due to the steeply sloping hills, vineyards are mainly cultivated on narrow terraces, in the southern and eastern part, vines were mainly cultivated in association with arable land in the traditional "piantata di viti". In 1929 75% of the specialised viticulture of the whole territory was concentrated in just four municipalities (Valdobbiadene, Farra di Soligo, Cison di Valmarino and Follina). Evidently, the analysed covariates relating to the physical characteristics of the land and the surrounding territory cannot fully account for the characteristics of the terroir and the fame that derives from it for the production of wines.

An element that emerged in the study, which is not reflected in other researches, is the effect of the planting expectations of a vineyard on the price of arable land and woods. As seen, the prices of these crops are very high and certainly not commensurate with their actual profitability in a hilly environment. It was also seen that the price was higher in the event that woods and arable land were quickly transformed into vineyards in the years following the sale. This is an effect similar to that highlighted by other authors in relation to the increase in the price of land resulting from the urbanization expectations of agricultural soils (Plantiga et al., 2002; Tempesta, 2018, p. 9) that in general can be defined as a "hope value[5]".

As pointed out by Plantiga et al. (2002, p.1) "current farmland prices are influenced by the potential for future land development". Buyers tend to capitalize the expected price increase in the current price and their willingness to pay depends on the amount of the price increase, the probability that it will occur and the time needed for the increase to take place.

However, it should be noted that correctly defining these elements is very complex and can easily lead to an overestimation of the property value due to the numerous cognitive biases that can affect the behaviour of buyers, such as the money illusion (Fisher, 1928; Shafir et al., 1997) and the use of heuristics in determining the probability that an event will occur (Tversky and Kahaneman, 1974). If expectations are irrational they can lead to the formation of speculative bubbles that can affect the stock market (Shiller, 2005), housing market (Lind, 2009) and farmland market (Engsted, 1996; Baker et al., 2014).

Our research also found that some subjective characteristics of the parties could influence the price paid. It has in fact been seen, that if the buyer was a company, the unit price was on average 24% higher. Few other studies have analysed this aspect of the land market. For example, Tsoodle, Golden and Featherstone (2006, p.1) found that "Transactions between related parties resulted in a 43% discount on the

[5] The concept of "Hope value is used to describe an uplift in value which the market is willing to pay in the hope of a higher value use or development opportunity being achievable than is currently permitted under development control, existing infrastructure constraints or other limitations currently in place" (TEGOVA, 2016, p. 24).

per acre sales price". A similar result was obtained by Perry and Robinson (2001) who pointed out that in sales between relatives or neighbours the price is significantly lower than when other parties are involved in the transactions[6].

To explain the price difference that we found, it is possible to suppose that companies and other types of buyers, at least partially, belong to different land market segments. In this regard it should be noted that the land purchased by companies has on average a larger surface area (2.45 ha against 0.65 ha) and a higher price (840,000 € against 130,000 €). On the other hand, one could assume that companies for financial reasons are induced to declare the true amount paid in the deed of sale, while other individuals declare a price value lower than the real one to reduce the transaction tax.

From the appraisal point of view, however, the problem arises of establishing what the real market value of the land is, since the presence of subjective factors can make the prices recorded by the deeds scarcely reliable. Moreover, as noted, the purchase of land can be motivated by two only partially overlapping purposes: economic and financial. In the first case, the aim of the purchase is to obtain a higher land income and this favours an improvement in the economic system and an increase in the value of land due to the transfer of land from inefficient farms to more efficient ones.

If the purposes are mainly financial and equity, people buy the land hoping to obtain a capital gain, like what happens in the stock markets.

However, while the purchase for economic purposes is based on budgetary data that are substantially objective, the purchase for financial purposes is influenced by highly subjective assessments on the future evolution of real estate values.

In this case, the decision biases mentioned above can become particularly important and often, as observed by Shiller (2005), the behaviour of market operators is influenced by the "telling story" that spread over time, information can often lack a real and objective confirmation[7]. The presence of price increase expectations determines the existence of disturbance factors in the land market which, especially in certain contexts, can make it extremely complex to identify the factors that contribute to the price formation. The problem therefore arises of understanding how reliable market prices are for estimating land values.

There are also other factors, of a more strictly operational nature that can affect the reliability of estimates based on market prices, such as the possibility that the sales samples detected may not be representative of reality as they consist of land that is more likely to be sold (sample selection bias) (Bigelow et al., 2020).

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[6] Note however that in our study the variable relating to transactions between relatives was not statistically significant.

[7] "When prices go up a number of times, investors are rewarded sequentially by price movements in these markets, just as they are in Ponzi schemes. There are still many people (indeed, the stock brokerage and mutual fund industries as a whole) who benefit from telling stories that suggest that the market will go up further. There is no reason for these stories to be fraudulent; they need only emphasize the positive news and give less emphasis to the negative" (Shiller, 2005 p. 67).

Lastly, according to our results, it should be pointed out that also by mean of HP models that have a high goodness of fit (e.g. high coefficient of determination, significant parameters, etc.), very relevant errors can be made in estimating the real estate values. Therefore, HP models have to be used cautiously in the professional appraisal practice.

Obviously, the limits of the research conducted cannot be overlooked from this point of view. First, it was not possible to detect the age of the vineyards or other temporary characteristics of the land. Secondly, the use of shapefiles relating to the various characteristics of the soil may have led to errors related to the scale of the maps dealing with the various themes considered or to the difficulty of a precise overlap between them and the cadastral maps. It was also not possible to elaborate productivity or unitary profitability indices, which would probably have improved the soundness of the estimates. As regards the easements, it was not possible to analyse the surface of the plots they occupy and the use of dummy variable can be misleading in this respect.

Now, however, it does not seem that models estimated with the HP method can be applied tout court by the valuers, despite their undoubted usefulness. The information obtained with these methods will certainly be useful for the appraiser who, however, will have to adapt it to the asset that he must evaluate, also in relation to the purposes of the estimate. Furthermore, in the scientific field, there remains the need to understand which other factors, in addition to those normally considered in the research conducted in this field, may influence the formation of prices at a local level. Moreover, particular attention should be paid to analysing the discrepancies existing between estimated values and market prices.

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