Agricultural land prices in France: between pure agricultural productivity and conversion options

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Abstract Theory and evidence show that agricultural land prices are influenced by factors other than the agricultural productivity and transportation costs as Ricardo and von Thünen suggested in the XIX century. Such factors are public policies and potential urbanization of land. In this study we extend the land development options by including vineyards and recreational activities (tourism). Results confirm the link between productivity and land prices but also the importance of the development options. Our findings could be used in public policy design for viticulture and they have implications on economic analysis based on agricultural land prices.

Keywords: land prices, hedonic models, land rent, agriculture, labeling
JEL codes: Q15, R52

This work was supported by the French National Research Agency (ANR) under the ORACLE project (ANR-10-CEPL-011).

1 Introduction

For more than three hundred years, agricultural land prices have been puzzling the scholars. Over the past few decades, research is generally focused on the effects of agricultural policy (following the work by Floyd, 1965) and the potential urban development (initiated by Capozza and Helsley, 1989). Nevertheless, land can be converted to other than the urban use. Thus, its price should be considered as the result of the capitalization of the gains from the present and the future land uses.

In this paper, we investigate the effects of several land uses on the agricultural land prices in France. Our model accounts for the current agricultural use, the potential urban

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and touristic development, and a switch to viticulture. The returns from agriculture are measured through land shadow prices obtained by a supply-side model accounting for public policy and heterogeneous farms. To the best of our knowledge, the use of land shadow prices in a hedonic land price model is an original contribution to the literature. In the course of the article we (i) present the theoretical background concerning land prices; (ii) propose a hedonic statistical model in support of the ideas presented; and (iii) make some conclusions on the possible implications of our findings in terms of public policy and future research.

2 Underlying theories

The remuneration of land as a factor of production (land rent) is one of the first subjects studied in economics theory before and after its emancipation as a separate discipline. There is a multiplicity of theories concerning land rent, the most influential amongst them being the work of Ricardo (1817) and von Thünen (1826). From the point of view of these two scholars, land rent originates from land's scarcity and is differentiated with respect to land productive capacity (Ricardo) and the distance from the market (both Ricardo and von Thünen). Rents are established in comparison with marginal land where the average costs of production or provision are the highest.

Land economic rent can have different origins. It is linked to agricultural productivity and to property rights. Because land is considered as an asset on financial markets, property rights give access to certain revenues (Trivelli, 1997; Guigou, 1982). It is generally assumed that land prices[1] reflect the Net Present Value (NPV) of future land rents. This straightforward link between observed prices and rents is, nevertheless, questionable (Clark et al., 1993; Gutierrez et al., 2007; Dupraz and Temesgen, 2012; Karlsson and Nilsson, 2013). Guiling et al. (2009) extend the NPV formula in order to include the possibility of land conversion to other uses.

1. We use agricultural land price (rent) and land price (rent) interchangeably.

Real options theory[2] and its applications to land pricing bring to light the relation between potential future land uses and current agricultural land prices (Capozza and Helsley, 1989; Plantinga et al., 2002). Land price is the NPV of future rents but rents can originate not only from agricultural activity but also from other land uses, such as urban, to which land may be converted in the future. For two possible land uses, agricultural and urban, Capozza and Helsley (1989) propose a representation which defines agricultural land price (P^A) as a function of time (t) and space (z) in relation to a central business district (CBD). They summarize it in Equation (1).

$$P^A(t,z) = \int_t^{t^*} Ae^{-\delta(\tau-t)}d\tau + \int_{t^*}^{\infty} R(\tau,z)e^{-\delta(\tau-t)}d\tau - Ce^{-\delta(t^*-t)}, \qquad t \in [0,t^*]. \qquad (1)$$

Agricultural rent is given by A, R is the development rent, C is the conversion cost, δ is the discount rate and t^* sets the moment when land is converted (irreversibly). Plantinga et al. (2002) base their research on a similar model and empirically show that option values of future land development are capitalized into agricultural land prices. Unlike previous studies where distance to cities has been associated only with a "von Thünen-type" rents, here the vicinity to cities is related to an option value for future development and its influence on agricultural land prices is explicit. Cavailhes and Wavresky (2003) show that farmland prices in immediate proximity to cities incorporate high premiums for urban conversion which fall sharply with the increase in distance.

Based on Equation (1), we consider land price as being composed of agricultural rent and option values for other land uses, where agricultural rent originates from a variety of factors. These include land productivity, capital invested (such as irrigation infrastructure, buildings), rent due to the proximity to markets (Cavailhès et al., 1996;

2. Initially applied to land in the context of environmental protection and irreversibility by Arrow and Fisher (1974) and Henry (1974).

Guigou, 1982).

$$P^A = \underbrace{f(\text{productivity}) + k(\text{capital}) + m(\text{distance to markets})}_{\text{agricultural rent}} + \underbrace{\sum_{i=1}^{n} l_i(\text{land use}_i)}_{\text{option values}} \qquad (2)$$

Functions f, k, l_i are supposed increasing and function m decreasing [3]. Each element in Equation (2) has its own temporal horizon. For this reason we assume that there are separate functions defining the way elements affect observed land prices. As there are many possible land uses other than the agricultural one, conversion to which may occur at different moments in time, we suppose also that there are separate functions specific for each one of them. Agricultural rent depends on commodity prices established on international markets [4]. Furthermore, as Latruffe and Le Mouël (2009) summarize in their study, land prices are generally found to be "more responsive to government-based returns than to market-based returns". We address this specificity of the land market by using results from a supply-side model of French agriculture which integrates the European Union Common Agricultural Policy (CAP).

We introduce in the analysis the urban and touristic development options along with the one for planting vineyards. The division between urban and touristic development is imposed by the data available. The urban pressure is generally captured by the population density and thus the touristic inflow is not taken into account. The latter can be, however, important and so demanding in terms of space needed for accommodation and amenities provision. Dachary-Bernard et al. (2011) propose an original study demonstrating the effects of the proximity to the seacoast on agricultural land prices.

In our study we also include viticulture, distinguishing it from the other agricultural uses, namely cereals, oilseeds, protein and other crops, and meadows. French wine exports accounted for 7.83 billion euro in 2012 [5]. Thus, viticulture represents the third largest

3. For the sake of simplicity, we assume separability between these components.
4. This is true for France since 2006 when a reform in the Common Agricultural Policy took place.
5. FranceAgriMer, Le marché du vin en 2012, http://www.franceagrimer.fr/filiere-vin-et-

export sector of the country. The plantation of new vines is currently limited to the areas where geographical indicators (GI) are established. These GI are either the Protected designation of origin (PDO) or the Protected geographical indication (PGI) as they are defined by the European Union legislation. This regulation is, in fact, restraining the wine production from expanding into regions other than those where it already exists. As we shall see in the "Materials and methods" (Section 3), vineyards' prices are significantly higher than those for arable land and meadows. Thus, when a parcel of arable land is subject to GI attribution due to its location, its price would, supposedly, reflect it. Geniaux et al. (2011) estimate the anticipations for land conversion under land use regulation through zoning and confirm the anticipations' influence on land prices for the French Provence region. One of the indicators they use is the presence of geographical labeling for wines distinguishing four different appellations of origin. All four have a positive effect on parcels' prices, two of which being significant at the 1% confidence level.

3 Materials and methods

Agricultural land market and land prices. Land market in France is regulated by a special structure called SAFER (Société d'aménagement foncier et d'établissement rural). Notaries have to inform SAFER for all property transfers envisaged. The latter can then execute its pre-emption right and acquire the land. In 2012, for instance, SAFER bought almost 18% of the total agricultural land traded, i.e. some 90,000 hectares (7,000 ha through its pre-emption right [6]). In our study we use agricultural land prices (of arable land and meadows) communicated by the French Ministry of Agriculture [7]. They are averaged at the scale of (groups of) small agricultural region (SAR [8]). Land traded differs widely in its characteristics and Ministry statistics account for arable land and

cidriculture/Vin/La-filiere-en-bref/Le-marche-du-vin-en-2012

6. SAFER, http://www.safer.fr/missions-safer.asp.
7. Statistical service of the Ministry, Agreste, http://agreste.agriculture.gouv.fr/.
8. SAR's area is varying from some 1,000 ha to more than 4 million ha.

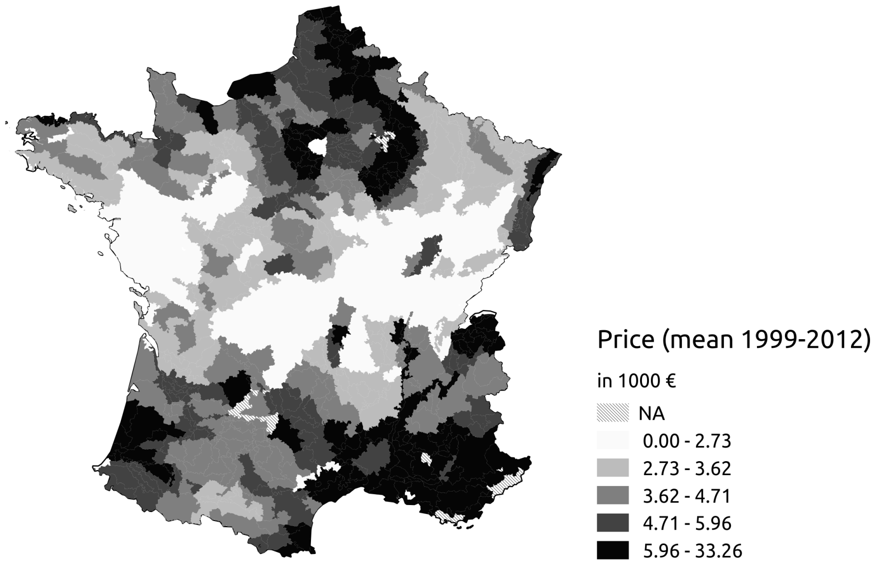
meadows alike (vineyards and orchards are not taken into account). In 2012, arable land price on average was 6,560 euro/ha (cereals), meadows are traded for an average of 4,220 euro/ha in regions with predominant animal husbandry, while a hectare of vineyards under PDO was traded for 131,700 euro (SAFER, 2013). Special attention is paid to the selection of property right transfers taken into account by Ministry statistics. For instance, transactions of less than 70 ares or where there are buildings present are not considered in the statistics. Only parcels with a certain agricultural vocation are included. The number of transactions per year is restraint and the characteristics of the land lots exchanged can vary from year to year. So, in order to have a better representation of land prices, we use the values for a 14 years period (from 1999 until 2012), expressed in 1999 euros [9], and calculate an average price. Figure 1a displays the territorial distribution of land prices.

Agricultural data. We use data from the general agricultural census conducted in 2010 [10] and provided by the statistical service of the French Ministry of agriculture. Data concerns the vineyards and the utilized agricultural area (UAA, all in hectares). The information is available at the French canton scale (there are approximately 4,000 cantons in France) and later aggregated at the (groups of) SAR level in order to ensure consistency with the data on land prices. A map of the share of GI vineyards in the total UAA is given in Figure 1b.

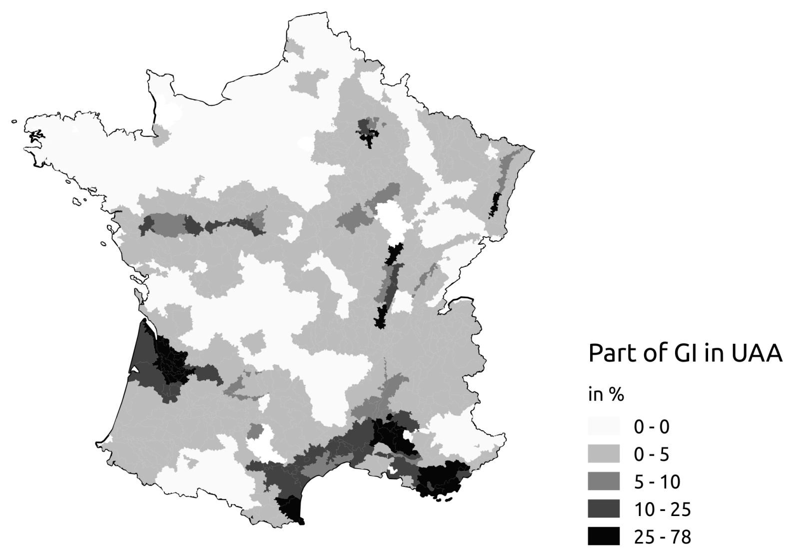
Demography and tourism. The data on population and revenues is provided by the French national statistical institute (INSEE) at the scale of the French commune. Density is then calculated and aggregated at the SAR level. The revenues across communes in the same (group of) SAR are averaged and expressed in euros per capita. INSEE provides us also with information concerning the domestic tourism consumption per administrative region (in millions of euro) and the number of vacation properties. This information is combined with the tourism density (number of beds per km^2) obtained

9. Inflation estimates for the period coming from the World Bank, `http://data.worldbank.org/indicator/NY.GDP.DEFL.KD.ZG`.

10. Agreste, `http://agreste.agriculture.gouv.fr/recensement-agricole-2010/`.



(a) Land prices per hectare at the level of (group of) SAR.



(b) Share of GI vineyards in total UAA at the level of (group of) SAR.

Figure 1. (**a**) Land prices per hectare (mean value) and (**b**) share of GI vineyards.

from the French Ministry of Sustainable Development [11]. All data transformations and aggregations are done using the R and the QGIS softwares.

Agricultural land rent. In order to identify the part of the agricultural returns capitalized in land prices, we use the land shadow prices calculated by the supply-side agricultural model AROPAj. Returns from agriculture in France depend not only on land quality and productivity. They depend as well on the attribution of different agricultural payments and production quotas defined in the Common Agricultural Policy (CAP) of the European Union. The model (for description, see, for instance, Galko and Jayet, 2011) focuses on the supply-side and is based on linear programming. It covers the European Union agriculture and takes into account the CAP. AROPAj agents are representative for about 85% of the UAA in France, 18 crops and 5 animal species. Our economic model is partly coupled with the crop model STICS (Godard et al., 2008) and is calibrated with the data from the Farm Accountancy Data Network (FADN). Economic agents in the model are groups of farms (farm types), each one maximizing its gross margin. There are some 150 farm types in France and they are representative at the FADN region level. Their exact geographical location is unknown [12]. Results from AROPAj are disaggregated (spatialized) at a 100 x 100 m scale grid and the probabilities of presence of the groups of farms in each grid cell are calculated through the method developed by Chakir (2009) and Cantelaube et al. (2012). Then, results are summarized at the (group of) SAR level and the average values per hectare are obtained.

An essential element of AROPAj is the optimal allocation of land between different agricultural activities. This is translated by a total surface constraint associated with a shadow price (dual value), the farm type's UAA being considered as a quasi-fix factor of production. This shadow price reflects the opportunity cost of the most profitable land use. We use the land shadow prices estimated by AROPAj and calibrated to FADN data for 2002. Their spatial distribution is represented on Figure 2. For perfectly competitive markets, land rent and dual value should coincide. This is not true in the case of France

11. Data available at `http://geoidd.developpement-durable.gouv.fr/`
12. Privacy policy of the FADN.

where the rental prices are fixed in an interval defined by the administrative authorities [13]. Shadow prices can be estimated econometrically (Dupraz and Temesgen, 2012) or derived through the maximization of farmers' profit function as it is done in the AROPAj model. Dupraz and Temesgen (2012) report a mean shadow price of 550 euros/ha/year which is a result close to the one obtained by AROPAj of about 570 euros/ha/year. The latter figure corresponds to a partially decoupled CAP policy following the Luxembourg reform of 2003. For both models data is provided by the FADN.

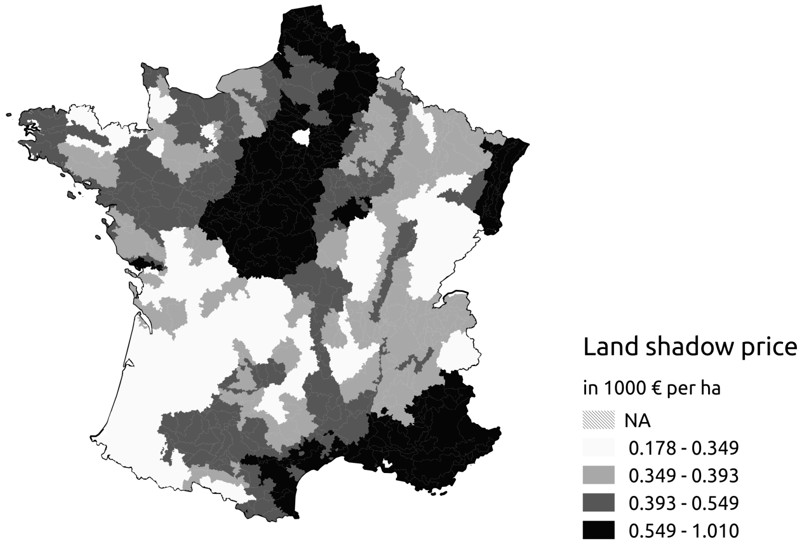


Figure 2. Land shadow price estimated by the AROPAj supply-side model (mean values per ha at the scale of (group of) SAR.

An important limitation of FADN data is the lack of labour costs. Thus, the remuneration of labour is redistributed to the other bounded factors of production that are taken into account in the objective function (duality theorem), in our case these are land, irrigation, CAP quotas and other (e.g. livestock, supposed to be quasi-fixed on the short term). By using the dual values calculated by AROPAj, we assume that labour costs are uniform between different agricultural activities.

13. French Rural Code, Article L411-11. In reality, in some parts of the country new tenants are often constrained to make additional payments under-the-counter to the former tenants or the landlords in order to obtain the lease or the property.

4 Results

Using the data described in Section 3, we test the influence of the three options for land conversion, namely urban, touristic and vines. To do so, we use the hedonic model of the land prices presented in Section 2.

Urban rent. We approximate the rent for urban development by multiplying the population density with the mean average revenue. In order to refer this rent to the agricultural land, we divide by the UAA in the (group of) SAR instead of the total surface. This procedure is applied to the other proxies (for tourism and for vines) as well.

Tourism. The three major touristic regions in France are the Parisian region (Île-de-France), the Riviera region (Provence-Alpes-Côte d'Azur) and the Rhône-Alpes region with its summit, the Mont Blanc. The inflow of tourists is not captured by population density. Nevertheless, it plays an important role in the local economy. To evaluate its influence we propose the composed indicator presented in Equation 3.

$$\text{Tourism rent} = \left(\begin{matrix} \text{Vacation} \\ \text{properties} \end{matrix} + \begin{matrix} \text{Number} \\ \text{of beds} \end{matrix} \right) * \frac{\begin{matrix}\text{Domestic touristic consumption} \\ \text{in the adm. region}\end{matrix}}{\text{UAA}} \tag{3}$$

Vineyards. The variable we use to approximate the possibility to convert arable land or meadows into vines is the share of vineyards under GI in the total UAA in the (group of) SAR. It would have been preferable to distinguish the rent from GI and that for viticulture in general, but in reality the share of GI vineyards in the UAA and the share of viticulture in the UAA are highly correlated (Pearson r coefficient of 0.91). Furthermore, as mentioned before, the potential vine plantation is associated with the establishment of a GI.

The first assessment of the impact of these variables that we present is based on a Generalized Additive Model specification (GAM, Hastie and Tibshirani, 1990; Wood, 2006). This model allows us to have an insight on the functional forms under which the variables influence land prices. Formally the model is given in Equation 4 where we use a logarithmic link function (g, it gives a better fit for the data) and assume a Gaussian distribution of land prices. One of the inconveniences of the GAM is that the results are difficult to interpret, e.g. there is no single coefficient per variable. This is why such models are often represented by graphics that depict the estimated functions. The results obtained are given in Figure 3 while the approximate significance of the estimated functions is provided in Table 1. The model explains about 76.3% of the total deviance. All terms are reported significant.

$$g(\mathbb{E}(P^A)) = \beta_0 + f_1(\text{Shadow price}) + f_2(\text{Urban rent}) + f_3(\text{Tourism rent}) + f_4(\text{Vineyards}) \quad (4)$$

As theory suggests, the dual value of land explains well land prices. Prices increase as the dual values increase. There is a slight decrease in the interval between 600 and 800 euro per hectare and a steep rise afterwards. Values in that interval (600 – 800 euro) are mainly observed in the region Centre, where agriculture is dominated by large cereal farms (more than 55% of the UAA is concentrated in farms of more than 100 hectares [14]). Thus, the lower per hectare price can be explained by the fact that in this region land is traded by big surface lots diminishing the per hectare price. Eliminating observations from this region results in an almost linearly increasing function between land price and dual value.

Vineyards have a positive influence on land prices for GI vines' share lower than 10%. The effect stabilizes for greater values. For the urban rent, the estimated function has a parabolic form. We should mention that the second half of the parabola is evaluated on a low number of observations resulting in a large confidence interval. We address this issue in Subsection 4.1. The tourism function is estimated as an increasing linear one after an abrupt drop at lower values. Equation 5 is based on the functional forms estimated in the GAM model (the logarithmic transformation for the urban and vineyards' rents).

14. http://agreste.agriculture.gouv.fr/recensement-agricole-2010/

We evaluate it with the standard Ordinary least squares (OLS) technique. Results from the estimation are presented in Table 2.

$$log(P^A) = \beta_0 + \beta_1 * (\text{Shadow price}) + \beta_2 * log(\text{Urban rent}) + \\ + \beta_3 * (\text{Tourism rent}) + \beta_4 * log(\text{Vineyards}) \quad (5)$$

All coefficients are significant at the 1% confidence level. The residuals satisfy the normal distribution hypothesis (the Jarque Bera test reports a p-value of 98%). Because of the cross-sectional character of our data, we run the Breusch-Pagan and the White tests for homoscedasticity. The p-values reported by the two tests are 0.64 and 0.88 respectively, which means that we cannot reject the homoscedasticity hypothesis. Figure 4 represents the Pearson r coefficients of correlation between the model variables. Although positive correlations between variables are reported, the values are lower than 70%. We, thus, consider the estimated model coefficients reliable.

4.1 Sensitivity analysis

Estimated coefficients remain robust (significance, sign and to some extent values) when explanatory variables are dropped one by one. As we mentioned above and as Figure 3 shows, the estimated functions for the Urban and Tourism rent are based on too few observations for the upper values. After we eliminate the maximal values for these two rents, we reestablished the GAM functions (three observations are dropped out of the 350 initially available). Newly estimated functions resemble those on Figure 3, except that the Urban function is strictly increasing. The Tourism function keeps the stark switch in its functional form at lower values. The scale of the effect for Tourism is significantly modified as the comparison between Figure 3 and 5 shows. The results of the OLS model remain robust for the Shadow Price and the Urban rents. Tourism's coefficient increases tenfold (from $5.076*10^{-7}$ to $3.314*10^{-6}$). The overall explicative power is lowered (the R^2 drops from 45% down to 40%) and the significance terms of the

Parametric coefficients:					
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	8.23040	0.02	414.8	<2e-16	***
Approximate significance of smooth terms:					
		edf	Ref.df	p-value	
Shadow price		6.947	7.682	<2e-16	***
Urban		2.992	3.284	4.31e-11	***
Tourism		6.591	7.128	1.18e-15	***
Vineyards		4.594	4.912	1.55e-4	***
Significance codes: 0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1					
Adjusted $R^2 = 0.761$, Deviance explained = 77.5%, n = 350					

Table 1. Intercept and approximate significance of smooth terms (Std. Error – standard error, edf – effective degrees of freedom, Ref.df – degrees of freedom for reference distributions).

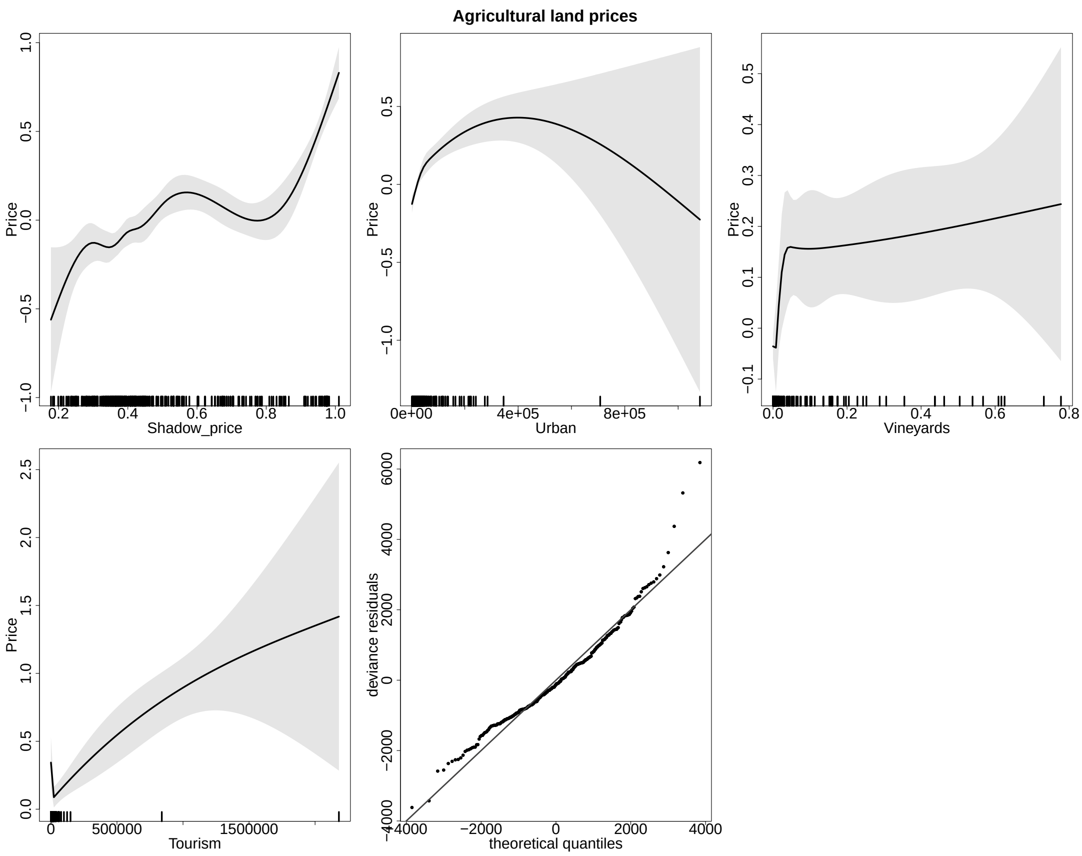


Figure 3. GAM smooth functions and residuals quantile-quantile plot. The observations' distribution is presented as a rug on the horizontal axis. On the vertical axis are land prices (0 equals the mean value). Plots per variable are done by assuming all other variables at their mean values. The shaded area represents the confidence intervals.

Parametric coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	6.588	0.18	37.183	<2e-16	***
Shadow price	0.9925	0.092	10.765	<2e-16	***
log(Urban)	0.1109	0.019	5.923	7.65e-09	***
Tourism	5.076e-07	1.363e-07	3.723	0.00023	***
log(Vineyards)	0.5921	0.2237	2.646	0.00851	**

Significance codes: 0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
Multiple $R^2 = 0.4535$, Adjusted $R^2 = 0.4471$
F-statistic: 71.56 on 4 and 345 DF, p-value: < 2.2e-16

Table 2. Parametric coefficients and significance (Std. Error – standard error, DF – degrees of freedom).

Vineyards and the Tourism coefficients deteriorate (from 0.00851 and 0.00023 to 0.04021 and 0.00696 respectively).

5 Conclusion

Land is a production factor not only for agriculture. As such, its price reflects the competition between different activities. Land rent theory puts agricultural land prices in relation to other land uses along with the pure agricultural land productivity. In order to demonstrate this, we propose a hedonic model decomposing French land prices into the different economic rents that define it. We capture the agricultural rent by using the land shadow price evaluated by a supply-side model which accounts for the CAP of European Union. We confirmed the influence of potential land conversions on land prices. The options we identified are the urban and touristic development along with the plantation of vineyards.

What implications do these results have? In 2014, France and some other wine producing countries succeeded in gaining cause to the European Union commission and, after months of struggle, the liberalization of the vine plantation was abandoned. The regime change proposed in the new CAP never took place and an alternative scheme is now under consideration. One of the arguments for the maintain of the production control was that vineyards currently occupy marginal lands. The potential liberalization,

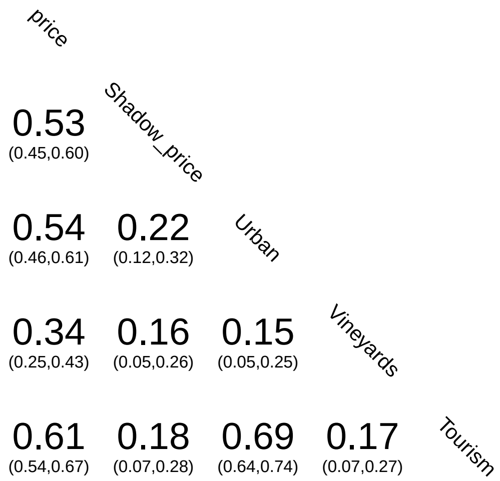


Figure 4. Pearson r correlation coefficients for the regression variables. Between brackets is given the confidence interval at 95% level.

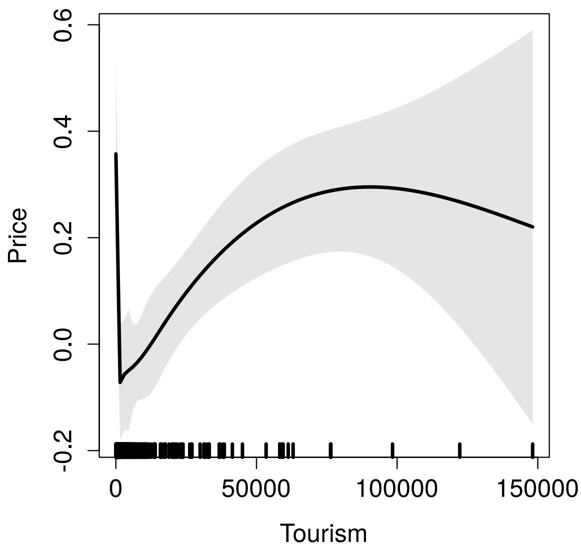


Figure 5. GAM smooth function for Tourism rent with maximal values for Urban and Tourism eliminated (three observations).

thus, could have resulted in the loss of arable lands due to vines' plantation because of their higher productivity. Our study shows that land prices are influenced positively by the possibility to convert to vineyards. So, the replacement of arable land by vines is a real prospect.

From methodological point of view, the present results confirm the capacity of economic models to evaluate the productivity of agricultural land. The advantage of such models is that the public policies could be easily translated into parameters or constrains of the maximization program. Thus, the effects of different regulations on agricultural activity could be assessed through their direct consequences on land returns. Furthermore, the land markets are not always well developed or land transactions could be rare. The shadow price can, in such cases, be used to obtain or refine estimations of land prices.

Another application of these results is in the sense of the Ricardian approach to climate change impacts assessment. This method, proposed initially by Mendelsohn et al. (1994), consists in explaining land prices by the present climate and evaluating the future prices following climate projections. One of its major hypothesis is the perfect mobility of the economic activities along with the well functioning land markets. As we showed in our analysis, land prices are not only influenced by the pure agricultural productivity but also by other factors some of which fixed in space (like the Riviera coast or the Alpes, for instance, as well as the GI wines). Thus, a rigorous assessment of climate change impacts based on this method should take into account these factors and capture their part in the land prices in order to prevent biases. For instance, Schlenker et al. (2005) in their analysis account for the effects of urban pressure on agricultural land prices following the foundings in Plantinga et al. (2002).

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