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The role of environmental and land transaction regulations on agricultural land price: The example of the French region Brittany

Abstract

In this paper, we investigate how environmental and land transaction regulations influence the price of agricultural plots sold in France. We use data from individual transactions for the period 1994-2010 in the NUTS2 region Brittany. Estimations were performed both ignoring and accounting for spatial interactions (model SARAR). Regressions on three sub-samples of buyers were performed in order to assess whether different buyers have different attitudes or plans regarding the purchased farmland: a sub-sample including only farmer buyers; a sub-sample including non-farmer individual buyers and; a sub-sample including non-farmer non-individual buyers. Results indicate that the price of land is lower when buyers are farmers, that the nitrate surplus area zoning increases the price of land, even more so for farmer buyers. Regarding land transaction regulations, there is a negative effect, on land price, of the purchaser being the current tenant or being the land regulating public body SAFER. Estimating the model on different sub-samples depending on the buyers' type sheds light on the factors which are more important for each type.

Keywords: farmland price, individual transactions, environmental regulations, SAFER regulation, spatial econometrics, Brittany (France)

JEL classifications: Q24, Q15, Q28

Impact des régulations environnementales et foncières sur le prix de la terre agricole : l'exemple de la région Bretagne en France

Résumé

Dans ce papier, nous analysons l'influence des réglementations environnementales et des réglementations ayant trait aux transactions foncières sur le prix de vente des terres agricoles en France. Nous utilisons des données de transactions individuelles pour la période 1994-2010 en Bretagne. Les estimations économétriques ont été réalisées sans et avec (grâce à un modèle SARAR) prise en compte des interactions spatiales. Afin d'évaluer si l'attitude vis-à-vis de la terre et les projets d'utilisation de la terre achetée varient selon les acheteurs, trois sous-échantillons d'acheteurs ont été considérés : les agriculteurs, les acheteurs particuliers non agricoles, et les autres acheteurs (hors particuliers, hors agriculteurs). Nos résultats indiquent que le prix des parcelles est plus faible lorsque l'acheteur est agriculteur, et qu'il est plus élevé dans les zones soumises à la Directive Nitrates, notamment pour les agriculteurs acheteurs. En ce qui concerne les réglementations ayant trait aux transactions, le prix des parcelles est plus faible lorsque l'acheteur est l'agriculteur actuellement locataire de la parcelle ou lorsqu'il s'agit de la SAFER. L'estimation du modèle sur les trois sous-échantillons permet de mettre en évidence les facteurs les plus importants pour chaque type d'acheteur.

Mots-clés : prix des terres agricoles, transactions individuelles, réglementations environnementales, SAFER, économétrie spatiale, Bretagne

Classifications JEL : Q24, Q15, Q28

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1. Introduction

The observation of time and space variations in prices of agricultural land has triggered a large body of literature on farmland price formation. Most of the research is based on the Ricardo capitalisation formula, where land price is given by the discounted value of expected agricultural revenues. However, the discrepancy between the development of agricultural revenues and the development of land prices has questioned the validity of this simple ricardian approach (Weersink *et al.*, 1999). In particular it is now well acknowledged that the pressure from non-agricultural activities, such as urban development, transport infrastructures, and tourism, plays an important role on farmland prices. It is also now well known that agricultural policies affect land price. In particular, agricultural subsidies are capitalised into land prices (for a review, see Latruffe and Le Mouël, 2009). Environmental regulations such as zonings may also be capitalised in land prices (Henneberry and Barrow, 1990; Vaillancourt and Monty, 1985; Le Goffe and Salanié, 2005). Institutional regulations may also affect the market for agricultural land. For example, land regulations are an important feature of developed countries, and may exist in the form of prohibited land ownership for specific entities, pre-emptive rights for specific buyers, restrictions regarding the size of the plot exchanged (Ciaian *et al.*, 2012), etc. In France in particular, land regulations are relatively strong, among the strongest in Europe (Van Herck *et al.*, 2012). How regulations of land transactions affect agricultural land price is nevertheless little known.

This paper contributes to this issue. The objective is to estimate the determinants of agricultural land price in a French region with individual transaction data during 1994-2010. In particular, we aim to assess the role of regulations that may affect the price of farmland transactions. We focus on the role of environmental and land transaction regulations on the price of agricultural land.

The paper is structured as follows. The next section presents the case study and some background on regulations. Section 3 explains the conceptual framework and Section 4 presents the data and variables used. Section 5 describes the results and the last section concludes.

2. Background: case study and regulations

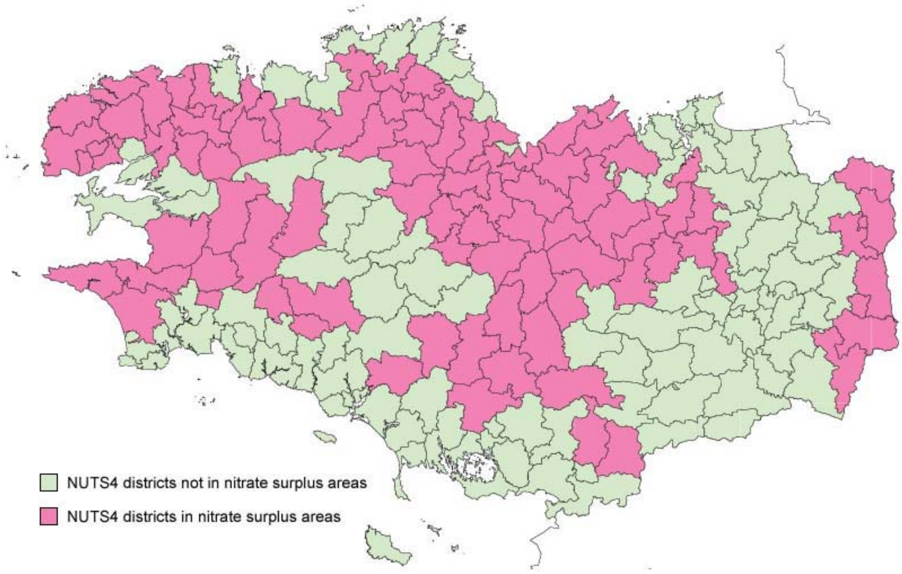
This section describes the region studied, and the regulations considered. The case study is Brittany, a French administrative region at the NUTS2[1] level located in Western France. It consists of four NUTS3 regions, 201 NUTS4 districts and 1,270 municipalities. The region has a strong agricultural character: it is among the first agricultural European regions. In particular it is the first region in the European (EU) in terms of milk production, with 3.7% of the EU production in 2010 (Eurostat, 2010). The region is also a big producer of pork, poultry products and vegetables. In 2010 it accounted for 20%, 54% and 22% of French farms specialised, respectively, in milk, pork and poultry (Agreste, 2011). In terms of farm structures, in 2010 the region accounted for 6%, 8% and 21% of, respectively, the French utilised agricultural area (UAA), number of farms and number of livestock units (DRAAF Bretagne, 2011).

Pollution from agriculture in Brittany is a crucial problem, in particular in terms of livestock dejections, resulting in high nitrogen rates in water and, more recently, in high concentration of green algae in some ocean bays. Following the 1991 EU Nitrate Directive (91/676/CEE) the whole region has been classified in nitrate vulnerable areas since 1994. This implies that all farmers in Brittany must comply with specific farming practices, such as keeping a yearly register with fertiliser quantities used on the farm, not using fertilisers outside specific periods and implementing grass buffer strips along rivers. In addition, some districts in the region are subject to more restrictive practices as they are classified in nitrate surplus areas (“*zones d’excédent structurel*”). This zoning is based on the quantity of livestock dejections in the district: if it would lead to a nitrogen quantity greater than the authorised ceiling of 170 kg per hectare, then the district is included in the zoning. There, farmers’ practices are more constrained, in terms of livestock head numbers, quantity of nitrogen produced, and use of manure. Figure 1 shows the districts in Brittany which are subject to such zoning since 2010. In 2010 about four out of ten NUTS4 districts in the region were subject to such zoning, and the average nitrogen quantity in the region was 178 kg per hectare (DRAAF Bretagne, 2012).

[1] The Nomenclature of Territorial Units for Statistics (NUTS) provides a single uniform breakdown of territorial units for the production of regional statistics for the EU. In France, NUTS2 corresponds to the French administrative regions (“*régions*”), NUTS3 corresponds to the French administrative sub-regions (“*départements*”) and NUTS4 corresponds to the French administrative districts (“*cantons*”). France (excluding overseas territories) consists of 22 NUTS2 regions and 96 NUTS3 regions.

(source: http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction).

Figure 1: Brittany's districts in the environmental zoning of nitrate surplus areas in 2010



Source: Observatoire de l'Eau en Bretagne

Adding to this is the fact that the region is densely populated and attractive in terms of population flows. In 2009, among the 22 NUTS2 regions in France, Brittany was the seventh most densely populated region with 116 inhabitants per square kilometre, the fifth region in terms of incoming population flows, and it had the lowest unemployment rate (9.3%) (INSEE, 2009). All this results in land use conflicts between agriculture and other uses, such as urban development. During 1990-2000 Brittany was the fifth French NUTS2 region in terms of rate of urbanisation of agricultural land, a situation slightly attenuated during 2000-2006, when it ranked seventh (INSEE, 2009).

Despite the urban development pressure, the price of agricultural land remains low in Brittany as in the rest of France. The average price of agricultural land (for plots larger than 0.7 hectare and excluding land with vineyards) in France in 2000 and 2010 was respectively 3,480 and 5,070 Euros per hectare, while the respective figures for Brittany were 3,120 and 4,980 Euros (Agreste, 2012). These figures are relatively lower than for most EU countries, whose average price is in general above 9,000 Euros per hectare (Figure 1 in Ciaian *et al.*, 2010). One reason for such low figures compared to other European countries may be the role of specific bodies regulating land transactions, the SAFERs ("Sociétés d'aménagement foncier et d'établissement rural") (Latruffe and Le Mouël, 2006). SAFERs are private bodies with public service missions to oversee land transactions in order to support the settlement of farmers, favour farm consolidation and limit farm enlargement, and avoid price speculation. For this, each plot transaction is notified by notaries to the local SAFER, which then has two months to approve or refuse the transaction. The transaction is accepted by the SAFER if it does not go against its above-mentioned missions. In the inverse situation, the transaction is rejected and the SAFER tries to reach a mutual agreement with the buyer and the seller. If this is not possible, SAFERs have a pre-emption right on the land exchanged: they can purchase land at a lower price than the original one, and re-sell it later at a lower price, or at the same price but to another buyer of their choice.

The situation described above is specific to France. In general additional regulations may exist which may affect land transactions in terms of market participation, such as inheritance laws, pre-emptive rights, and restrictions on land ownership or land use (Latruffe and Le Mouël, 2006). In this paper we consider the case of the pre-emptive right benefitting to the current tenant farmer. A farmer renting in a parcel of land has a pre-emptive right for the purchase of the parcel if the landlord decides to sell. This means that the tenant farmer has priority in the purchase when the land is put up to sale, or can become the new owner even though another person has bought the land, and this, up to one month after the purchase by this person. This regulation ensures that the farm using the land to sale is not affected by the sale, and gives incentives to tenant farmers to become owners and therefore improve the use of land (Boinon, 2011). The tenant farmer must however satisfy several criteria: having been a farmer for the past three years at least, owning less than a specific size of land and committing to him or herself farm the purchased land during at least nine years.

While it is clear that SAFER's intervention may affect the price of sold agricultural land, it is less clear how tenants' pre-emptive rights would influence it. As explained by Latruffe and Le Mouël (2006), such rights restrict the number and type of potential buyers. But the effect on the price is not clear. As for the EU Nitrate Directive which aims at limiting the quantity, per hectare of land, of nitrogen released by livestock, it may increase the demand for agricultural land and as a consequence its price.

3. Conceptual framework and econometric strategy

3.1. Conceptual framework

The Present Value Model (PVM) is used here as the basic framework. The PVM model stipulates that the price of land is equal to the capitalisation of the expected revenues generated by land. More precisely, assuming that the use of land is on an infinite horizon, the value of land at a period *t* is given by the sum of the discounted revenues from land. In mathematical terms (Weersink *et al.*, 1999):

$$L_t = \sum_{i=1}^{\infty} \frac{E_t R_{t+i}}{(1+r_{t+1})(1+r_{t+2})...(1+r_{t+i})} \quad (1)$$

or

$$L_t = \int_{i=1}^{\infty} E_t R_{t+i} e^{-r_{t+i} s} ds \quad (2)$$

where L_t is the value of land at period *t*; R_{t+i} is the agricultural revenue generated at period *t*+*i*; r is the time-varying discount rate; E_t represents the expectation of the revenue on the basis of information available in period *t*.

An extension of the basic PVM model consists in accounting for the fact that agricultural land price is not solely determined by the revenue generated by agricultural activities, but is also affected by the possibility for land to be converted for other uses (*e.g.*, urban development, transportation or tourism infrastructures). Hence, an opportunity cost component (*i.e.*, rent from alternative uses) is added to the agricultural component of land price (Plantinga and Miller, 2001; Goodwin *et al.*, 2003), as follows:

$$L_t = \int_{i=1}^{i*} \left(E_t R_{t+i} e^{-r_{t+i} s} \right) ds + \int_{i=i*}^{\infty} \left(E_t X_{t+i} e^{-r_{t+i} s} \right) ds \quad (3)$$

where X is the rent generated from alternative uses of land; i^* is the period at which the conversion to a non-agricultural use occurs.

According to model (3), the current value of agricultural land is a non-linear function of rents stemming from agricultural activities, of rents stemming from potential future conversion of land to alternative uses, and of the discount rate.

In this paper we account for regulations that affect the market of agricultural land, and that may therefore affect its price. For this, as proposed by Plantinga *et al.* (2002), a random parameter specification is used. The model used is a specific case of the random parameter model developed by Hildreth and Houck (1968), Swamy (1970), and Swamy and Tinsley (1980). As suggested by Hornbaker *et al.* (1989) and used by Plantinga *et al.* (2002) in the case of agricultural land price, the parameters to estimate are not fixed but are a function of specific explanatory variables, here in particular regulations. Such specification is appropriate for the assessment of the role of regulations on land price. Indeed, while some regulations affect land prices directly only (*e.g.*, the intervention of SAFER), the environmental regulations in particular may affect land prices directly but also indirectly, through the basic factors of the PVM model: the agricultural revenue *R* and the rent of alternative land uses *X*.

The random parameter model of land price is:

$$L_p = \alpha_{0p} + \alpha_{1p} R_p + \alpha_{2p} X_p + \mu_p \qquad (4)$$

where subscript *p* denotes the observation level (plot transaction); μ_p is a white noise; and the parameters to estimate, α_{0p}, α_{1p} and α_{2p}, can be written as functions of specific explanatory variables *Z*, including regulations, as follows:

$$\alpha_{jp} = \delta_{j0} + \sum_z \delta_{jpz} Z_{pz} + \upsilon_{jp} \qquad (5)$$

where υ_{jp} is a white noise; δ_{j0} and δ_{jpz} are parameters.

The land regulations considered here (see below) are assumed to directly affect the land price, while the environmental regulation considered is assumed to affect land both directly and indirectly. In addition, other explanatory variables from *R* and *X* may also affect land price indirectly as well as directly. Therefore, the land price model can be written as follows:

$$\begin{aligned} L_p = & \left(\delta_{00} + \sum_z \delta_{0pz} Z_{pz} + \upsilon_{0p}\right) + \left(\delta_{10} + \sum_z \delta_{1pz} Z_{pz} + \upsilon_{1p}\right) R_p + \left(\delta_{20} + \sum_z \delta_{2pz} Z_{pz} + \upsilon_{2p}\right) X_p \\ & + \alpha_{Zland,p} Zland_p + \alpha_{Zenv,p} Zenv_p + \mu_p \end{aligned} \qquad (6)$$

where $Zland_p$ are the land regulations variables; Z_{pz} are explanatory variables excluding land regulations but including environmental regulation $Zenv_p$; δ_{00}, δ_{10}, δ_{20} and δ_{0pz}, δ_{1pz}, δ_{2pz}, $\alpha_{Zland,p}$ and $\alpha_{Zenv,p}$ are parameters.

Model (6) can be estimated as a heteroscedastic model using Feasible Generalised Least Squares (FGLS), as the model can be rewritten as follows:

$$L_p = \left(\delta_{00} + \sum_z \delta_{jpz} Z_{pz}\right) + \left(\delta_{10} + \sum_z \delta_{jpz} Z_{pz}\right) R_p + \left(\delta_{20} + \sum_z \delta_{jpz} Z_{pz}\right) X_p + \alpha_{Zland,p} Zland_p + \alpha_{Zenv,p} Zenv_p + \xi_p \quad (7)$$

with

$$\xi_p = \upsilon_{0p} + R_p \upsilon_{1p} + X_p \upsilon_{2p} + \mu_p \quad (8)$$

Model (7) is the model to be estimated. However, the potential rents from agricultural activity (R) and the potential rents from alternative uses (X) for each plot considered are not observed. In general the literature uses proxies enabling to capture the production potential of the land (for R) and the demographic and development pressures (for X). Here we also use proxies and we assume that they represent the rents as a linear function. The potential rents from agricultural activity are thus modelled by equation (9) and the potential rents from alternative uses by equation (10):

$$R_t = f\left(\sum_{h=1}^{H} RV_{ht}\right) = \sum_{h=1}^{H} RV_{ht} \quad (9)$$

$$X_t = g\left(\sum_{h=1}^{H} XV_{ht}\right) = \sum_{h=1}^{H} XV_{ht} \quad (10)$$

where *f* and *g* are linear functions; RV_{ht} are proxies for the agricultural rent; XV_{ht} are proxies for other rents.

We estimated the model with FGLS on the pooled sample (*i.e.*, all years together), including control variables in an additive form: whether the buyer is farmer or not; and some year dummies.

3.2. Accounting for spatial heterogeneity and autocorrelation

Besides the effect of fundamental explanatory variables which can be derived from the theory, land prices may also be influenced by spatial interactions among sold plots. Data on land prices may indeed be spatially associated (spatially autocorrelated or spatially heterogeneous) (Paez *et al.*, 2001). Two issues may arise that have to be considered when estimating model (7): the spatial heterogeneity and the spatial autocorrelation. As explained by Patton and

McErlean (2003), spatial heterogeneity would indicate that there exist spatially distinct land sub-markets, while spatial autocorrelation would reveal spatial lag dependence. The authors also stress that not accounting for these spatial issues during the estimations may result in parameter estimates that are biased.

The literature on spatial economics often relies on the use of the SARAR model in econometric estimations (Anselin and Florax, 1995; Kelejian and Prucha, 1998, 2010). The SARAR model is a generalisation of the spatial autoregressive model (SAR) proposed by Cliff and Ord (1973, 1981) with spatial autoregressive disturbance terms. The SARAR model, that is to say the spatial autoregressive model with autoregressive disturbances, can account for spatial lags in the dependent variable, in the exogenous variables, and also in the disturbance terms (Kelejian and Prucha, 2010).

We used the SARAR model, and assumed that the spatially weighted average of land prices neighbouring plot *p* (*i.e.*, the spatial lag) affects the price of this plot *p* (through indirect effects), in addition to the effect of standard explanatory variables. We also assumed that there is one or more omitted variables in our model and that the omitted variables vary spatially. Due to the unobserved heterogeneity or dependence, the error term tends to be spatially autocorrelated.

Model (7) can thus be written in a compact form including spatial effects, as in equation (11):

$$L = \lambda WL + \beta B + \mu \tag{11}$$

with

$$\mu = \rho W \mu + \varepsilon \tag{12}$$

where λ and ρ are scalar parameters indicating the extent of spatial effects; W is a weight matrix indicating the spatial structure of the data; WL and $W\mu$ are the spatial lags of L and μ, respectively; ε is a random term normally distributed such that it is $iid\left(0, \sigma_\varepsilon^2 I\right)$; and B are the explanatory variables of model (7) and β their associated coefficients.

In our data set the plot observations were geo-coded according to their location in one of Brittany's municipalities. We assumed that all observations within the same municipality were uniformly distributed, and that their locations were approximated by the municipality centroid. Thus, we computed a $n \times n$ (with *n* the number of observations) spatial weight matrix *W* in which a neighbour set was specified for each observation based on the Euclidean distance criterion. Considering an inverse-distance function we assumed that all units (*i*,*j* observations) were neighbours[2], because the spatial weights decreased with the distance. Self-neighbours were excluded, such that the diagonal elements of *W* were zero. In addition, the weight matrix was row-standardized, such that the sum of the elements of each row was unitary. Finally, given the size of our sample, the inverse-distance matrix was truncated and stored in a banded form.

Spatial autocorrelation and heterogeneity have to be treated together (Anselin, 1988). Therefore, we estimated the model with the generalized spatial two-stage least squares estimator (GS2SLS) (Kelejian and Prucha, 1998, 1999). The estimation procedure was performed in three stages. In the first stage equation (11) was estimated with two-stage least squares (2SLS) and an instrumental variable matrix *H* defined as follows:

$$H = \left(B, WB, W^2 B\right) \tag{13}$$

In the second stage the first-stage residuals were used to estimate, with the generalised method of moments (GMM), the autoregressive parameter ρ of equation (12) (Kelejian and Prucha, 2010). The last stage consisted in using ρ to apply a Cochrane-Orcutt transformation to equation (11) before estimating this transformed equation with 2SLS (Kelejian and Prucha, 2010).

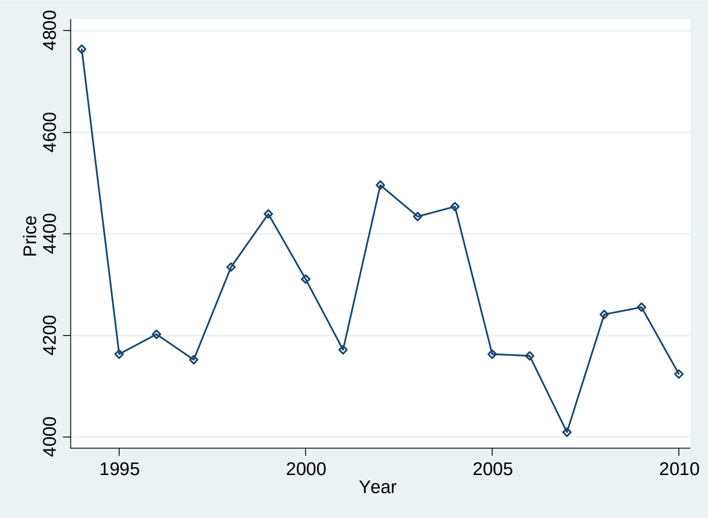
4. Data and variables used

4.1. Data

Our data were extracted from the database of all individual transactions of arable and pasture land which occurred in Brittany between 1994 and 2010, collected by notaries (the “PERVAL” database). We excluded built land and very small plots, namely less than 0.15 hectares. Such plots were very expensive and reflect the possibilities to convert to development use. We also removed outliers. In the end, the database that we used consisted in 14,991 sale transactions over the whole period for the region. The dependent variable, plot price, is the price per hectare of the exchanged plot. All variables in values were deflated by the yearly French price consumer index with base 2005.

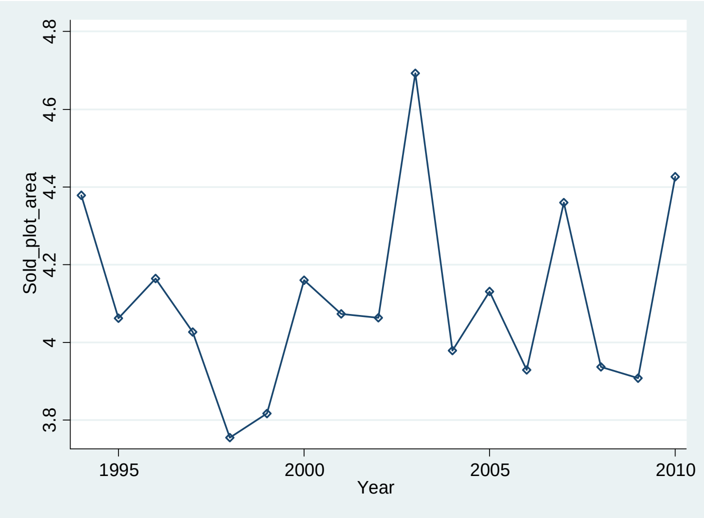
[2] An alternative way would be to consider that the elements *Wi,j* of *W* are non-zero when observations *i* and *j* are neighbours within a specific distance, and zero otherwise.

Figure 2: Evolution of the average deflated agricultural land prices (Euros per hectare) in Brittany between 1994 and 2010



Source: authors' calculations based on notaries' data

Figure 3: Evolution of the average plots' area (hectares) in Brittany between 1994 and 2010



Source: authors' calculations based on notaries' data

Figure 2 presents the evolution of the average agricultural land prices in Brittany between 1994 and 2010 in the sample used. The average price during the period was 4,275 Euros per hectare (with a minimum of 1,018 and a maximum of 24,558 Euros), which is in the range of average agricultural land prices in France (SAFER-Agreste, 2012). The yearly average prices have slightly fluctuated during the period but remained between 4,000 and 4,800 Euros per hectare. Figure 3 shows the evolution of the average area of the sold plots over the period considered. The yearly average plot area fluctuated around 4 hectares; the average for the whole period was 4.1 hectares (with a minimum of 0.15 and a maximum of 74 hectares).

4.2. Variables used in the econometric model

Table 1 defines the variables used. The dependent variable (*L*) was the price per hectare for the exchanged plot, that is to say the value of the transaction divided by the area of the plot sold. The discount rate (*r*) was the yearly interest rate observed at the country level. The proxies related to agricultural rents (*RV*) were: the average agricultural gross margin per hectare of UAA for the municipality where the plot was located; the area of the sold plot; the number of agricultural family working units per hectare of UAA in the municipality where the plot was located; weather variables observed in the municipality where the plot was located (namely quantity of rain and atmospheric radiation) and; soil characteristic observed in the NUTS4 district where the plot was located (namely cation exchange capacity). The proxies related to other rents (*XV*) were all measured at the municipality level and included: the population density; the number of second homes per hectare of municipality's area; the growth rate of land urbanisation; the attractiveness measured by the employment concentration rate and; whether the plot's municipality was located in an urban area.[3]

As for regulations, they consisted in environmental (*Zenv*) and land transaction (*Zland*) regulations. The environmental regulation included one proxy, namely whether the plot was located in a zoning nitrate surplus area. The land regulations included two dummy variables: whether the buyer was SAFER; and whether the plot was currently farmed by the buyer. In addition, a control variable representing whether the buyer was a farmer was included in the regression, as well as some year dummies.

[3] The employment concentration rate is the ratio between the number of jobs available in a municipality divided by the number of persons living in this municipality and holding a job inside or outside the municipality. Is considered as urban an area where housing constructions are close to each other (less than 200 meters away), with more than 2,000 inhabitants, where at least 10,000 jobs are available, and which is not located in the suburbs of another urban area (INSEE, 2009).

Table 1: Description of the variables used in the regression

Variables	Year of observation	Observation level	Source
Dependent variable L			
Land price per hectare of plot area	1994-2010	Plot	Notaries
Interest rate r			
Interest rate	1994-2010	Country	Statistical Office INSEE
R variables			
Agricultural gross margin per hectare of UAA	2000, 2010	Municipality	Agricultural Census
Sold plot's area	1994-2010	Plot	Notaries
Number of family working units per hectare of UAA	2000, 2010	Municipality	Agricultural Census
Quantity of rain	2000-2008	Municipality	Météo France
Atmospheric radiation	2000-2008	Municipality	Météo France
Soil cation exchange capacity	Averages for sub-periods 1995-1999, 2000-2004, 2005-2009	NUTS4 district	Réseau de Mesures de la Qualité des Sols (RMQS), GIS Sol
X variables			
Population density	1990, 1999 and 2009	Municipality	Statistical Office INSEE
Number of second homes per hectare of municipality's area	1990, 1999 and 2009	Municipality	Statistical Office INSEE
Growth rate of urbanisation	1990-2000 and 2000-2006	Municipality	Corine Land Cover
Attractiveness measured by the employment concentration rate	1990, 1999 and 2009	Municipality	Statistical Office INSEE
Urban area location or not [a]	2000, 2010	Municipality	Statistical Office INSEE
Zenv variable			
In nitrate surplus area or not [a]	2005, 2010	NUTS4 district	Regional office of the Ministry of Environment
Zland variables			
The buyer is SAFER or not [a]	1994-2010	Plot	Notaries
The plot is currently farmed by the buyer or not [a]	1994-2010	Plot	Notaries
Control variable			
The buyer is a farmer or not [a]	1994-2010	Plot	Notaries

[a] Dummy variables (1 if yes; 0 if no)

It should be noted that variables were not observed at the same geographical level (plot or municipality or NUTS4 district level) and were observed for different periods: for example, transaction's characteristics were available for each year during 1994-2010, variables extracted from the Agricultural Census were for municipalities and for the years 2000 and 2010, variables extracted from the Population Census were for municipalities and for the years 1990, 1999 and 2009, weather variables were for municipalities and for each year between 2000 and 2008, and the soil variable was the average at the NUTS4 district level for the sub-periods 1995-1999, 2000-2004 and 2005-2009. Regarding nitrate surplus area zoning, the regulation has been implemented in 1994 and revised in 2005 and 2010. Throughout the revisions, some NUTS4 districts have changed status (within or without the zoning).

To deal with the issue of different periods of observation depending on the variables, during the full period covered by the transactions (1994-2010) we considered for each year the closest period available. For example, in 2008 data from the 2010 Agricultural Census and from the 2009 Population Census were used.

For some variables there was no information for some observations. The final sample used thus reduced to 13,743 observations. Table 2 presents descriptive statistics of the variables used in the estimation.

Table 2: Descriptive statistics of the variables used in the regression: full sample (13,743 observations)

Variables	*Unit*	*Average for the period*
Dependent variable L		
Land price per hectare	Euros per ha	4,303
Interest rate r		
Interest rate	%	4.6
R variables		
Agricultural gross margin per hectare of UAA	Euros per ha	5,336
Sold plot's area	Hectares	4.1
Number of family working units per hectare of UAA	Number per ha	0.04
Quantity of rain	Millimetres	855
Atmospheric radiation	J^{-5}/square cm	9.24
Soil cation exchange capacity	cmol+/kg	9.6
X variables		
Population density	Inhab. per km²	83.7
Growth rate of urbanisation	%	1.6
Number of second homes per hectare of municipality's area	Number per ha	0.05
Attractiveness measured by the employment concentration rate	%	66.4
Urban area location or not [a]		0.37
Zenv variable		
In nitrate surplus area or not [a]		0.63
Zland variables		
The buyer is SAFER or not [a]		0.03
The plot is currently farmed by the buyer or not [a]		0.41
Control variable		
The buyer is a farmer or not [a]		0.62

[a] Dummy variables (1 if yes; 0 if no)

Following model (6), we assumed that the environmental regulation (*Zenv*) affects the agricultural land price directly as it may be less easy to convert land to non-agricultural uses in this area. We also assumed that it affects land price indirectly through the random parameters, as it may in fact affect the revenue generated by agricultural or non-agricultural uses of land. It was also expected that some specific variables affect land prices through the revenues (agricultural revenue *RV* and other revenue *XV*). More precisely, it was assumed that the following variables influence the gross margin per hectare (which is one of the proxies for agricultural revenue): the interest rate, the plot’s area, the number of family working units per hectare of UAA, the location in an urban area or not, all weather and soil variables, and the environmental regulation. Finally it was assumed that the following variables influence the population density (which is one of the proxies for other revenue): the atmospheric radiation, the number of second homes per hectare, the rate of urbanisation, the employment concentration rate, the location in an urban area, and the environmental regulation.

Expectations regarding the total (indirect and direct) influence of explanatory variables on land price were as follows. We expected a positive effect, on land price, from revenue proxies that are positively correlated with revenues and a negative effect from revenue proxies that are negatively correlated with revenues (whether revenues from agriculture *R* or revenues from alternative uses *X*). Regarding environmental regulations (*Zenv*), the zoning, that is to say the nitrogen constraint imposed by the Nitrate Directive, was expected to have a positive effect on land price. As mentioned above, the nitrogen limit imposed by the regulation implies that farmers need to spread manure on an increasing land surface. The resulting increasing demand for agricultural land would result in an increase in price. As for land regulations (*Zland*), we expected the dummy variable indicating whether the buyer is SAFER to have a negative effect on land price due to its possibility to pre-empt plots for which the price is too high and to sell them back at a lower price. As explained above, we had no expectation on the sign of the effect of the dummy variable indicating whether the buyer is the current tenant. As for the control variable indicating whether the buyer is a farmer, we expected a negative price. The reason behind this is that a non-farmer buyer may be willing to pay a higher price than a farmer, as the planned use of land may not be agricultural and therefore the future land revenue is expected to be higher.

4.3. Econometric models

The model was estimated firstly ignoring, and secondly accounting for, spatial interactions.

The model was estimated for the full sample of all buyers, but also for three sub-samples depending on the characteristic of the buyer. The first sub-sample included farmer buyers only. The second and third sub-samples included non-farmer buyers only. The difference between these two non-farmer sub-samples was that the second sub-sample included individual non-farmer buyers, while the third sub-sample included the other non-farmer buyers, and in particular SAFER and public buyers such as town councils. The objective of estimating the model for different sub-samples was to assess whether different buyers have different behaviour or plans for the plot purchased.

Therefore, in total eight models were estimated.

5. Results

Table 3 presents the explanatory variables' marginal effects obtained from the econometric estimation ignoring spatial interactions. The second column of the table relates to the estimation for the whole sample. Most of the explanatory variables have the expected sign. Regarding the agricultural revenue proxies, as expected, the gross margin per hectare and the number of family working units per hectare positively influence land price. The quantity of rain and atmospheric radiation decrease the price. However, the plot size has a negative effect while a positive effect was expected. All variables proxying the revenue from non-agricultural uses have the expected sign, namely a positive one (*i.e.,* the land price increases with an increased urbanisation pressure).

The environmental regulation variable has a positive effect on the land price, suggesting, as expected, that land prices increase with such regulations due to land competition. Regarding the land transaction variables, it is interesting to note that the SAFER intervention does not have a significant effect on the sale price. The variable indicating whether the land is currently tenanted by the farmer buyer has a negative effect. This may suggest that those buyers, knowing that they have priority in purchasing the land, may succeed in reducing the land price in the absence of other buyers' competition. As for the control variable which is whether the buyer is a farmer, it has a negative sign, confirming that farmers pay less for land than non-farmer buyers.

The estimation was then performed on the three sub-samples described above. The third column of Table 3 reports the marginal effects for the estimation on the sub-sample of farmer buyers, while the fourth and fifth columns report the marginal effects for the estimation on the sub-samples of, respectively, individual non-farmer buyers and non-individual non-farmer buyers. The gross margin plays a significant positive role for farmer buyers and for individual non-farmer buyers, but the effect is stronger for farmer buyers. The quantity of rain positively influences the price of land purchased by farmers, suggesting a climatic effect on harvests, but negatively influences the price of land purchased by individual non-farmers, suggesting a

Table 3: Results of the regression ignoring spatial interactions: marginal effects

	Whole sample (sub-samples 1+2+3)	**Farmer buyers (sub-sample 1)**	**Non farmer individual buyers (sub-sample 2)**	**Non farmer other buyers (sub-sample 3)**
Interest rate r				
Interest rate	-0.1259	-0.1352	n.s.	n.s.
R variables				
Agricultural gross margin per hectare of UAA	7.51 E-05	1.45 E-04	7.92 E-05	n.s.
Sold plot's area	-0.0211	-0.0084	-0.0280	-0.0303
Number of family working units per hectare of UAA	11.1567	16.5946	n.i.	n.i.
Quantity of rain	-0.0003	0.0004	-0.0020	n.s.
Atmospheric radiation	-0.0197	-0.0207	n.s.	0.1909
Soil cation exchange capacity	-0.1444	-0.0869	-0.1490	-0.2957
X variables				
Population density	0.0068	0.0057	0.0025	0.0103
Number of second homes per hectare of municipality's area	1.4334	n.s.	4.2324	n.s.
Growth rate of urbanisation	n.s.	n.s.	n.s.	n.s.
Attractiveness measured by the employment concentration rate	0.0009	-0.0011	0.0021	0.0025
Urban area location or not	0.3668	0.3913	0.2581	0.4405
Zenv variable				
In nitrate surplus area or not	0.5800	0.6090	0.4587	0.3372
Zland variables				
The buyer is SAFER or not	n.s.	n.i.	n.i.	-0.5283
The plot is currently farmed by the buyer or not	-0.6676	-0.5604	n.i.	n.i.
Control variable				
The buyer is a farmer or not	-0.2868	n.i.	n.i.	n.i.
R-squares	*0.23*	*0.34*	*0.10*	*0.17*
Number of observations	*13,743*	*8,485*	*3,564*	*1,457*

n.s.: marginal effect not available (parameters in the regression not significant).
n.i.: variable not included in the regression.

Table 4: Results of the regression accounting for spatial interactions (model SARAR): marginal effects

	Whole sample (sub-samples 1+2+3)	**Farmer buyers (sub-sample 1)**	**Non farmer individual buyers (sub-sample 2)**	**Non farmer other buyers (sub-sample 3)**
Interest rate r				
Interest rate	-0.1524	-0.1493	n.s.	n.s.
R variables				
Agricultural gross margin per hectare of UAA	9.24 E-05	5.81 E-05	7.14 E-05	n.s.
Sold plot's area	-0.0187	-0.0138	-0.0582	-0.0327
Number of family working units per hectare of UAA	11.6267	16.8338	n.i.	n.i.
Quantity of rain	-0.0007	n.s.	-0.0024	n.s.
Atmospheric radiation	-0.0276	n.s.	n.s.	0.0989
Soil cation exchange capacity	-0.0956	-0.1015	-0.1545	-0.3328
X variables				
Population density	0.0067	0.0023	0.0015	0.0101
Number of second homes per hectare of municipality's area	1.4338	n.s.	4.3915	n.s.
Growth rate of urbanisation	n.s.	n.s.	n.s.	-0.0178
Attractiveness measured by the employment concentration rate	0.0010	-0.0010	0.0022	0.0029
Urban area location or not	0.2499	0.3299	0.2579	0.4488
Zenv variables				
In nitrate surplus area or not	0.6000	0.6100	0.2476	0.4092
Zland variables				
The buyer is SAFER or not	n.s.	n.i.	n.i.	-0.5957
The plot is currently farmed by the buyer or not	-0.8395	-0.6645	n.i.	n.i.
Control variable				
The buyer is a farmer or not	-0.3767	n.i.	n.i.	n.i.
Spatial parameters				
Lambda (λ)	0.2376	0.1997	0.2048	0.1531
Rho (ρ)	-0.1732	-0.0401	-0.1022	-0.1134
Number of observations	*13,743*	*8,485*	*3,564*	*1,457*

n.s.: marginal effect not available (parameters in the regression not significant).
n.i.: variable not included in the regression.

disinterest for areas with too much rain. The variables influencing the revenue from non-agricultural uses play similarly on the price of land purchased by farmer buyers and by non-farmer buyers, except for the attractiveness measured by the employment concentration rate. As expected this variable has a positive influence on the price of land purchased by non-farmer buyers, showing the effect of population pressure. However it has a negative influence on the price of land purchased by farmers. Except for the number of second homes which has a non significant effect on the price paid by non-farmer non-individual buyers, for this sub-sample the effects of the X variables are the strongest among all sub-samples. The environmental regulation variable positively influences the price paid by all types of buyers. However, the effect is stronger for the sub-sample of farmer buyers suggesting strong competition for agricultural land among farmers. The non-significant effect of the SAFER found in the estimation for the whole sample is not confirmed. In fact, the variable has a significant negative effect on the price paid by non-farmer non-individual buyers, as expected.

Table 4 similarly presents the results from estimations accounting for spatial interactions (model SARAR). All signs of significant coefficients are confirmed. Only two coefficients become non-significant: the coefficient of the quantity of rain and the coefficient of the atmospheric radiation for the estimation on the sub-sample of farmer buyers.

6. Conclusion

Using data from individual transactions for the period 1994-2010 in the French NUTS2 region Brittany, we investigated how environmental regulations and land transaction regulations influence the price of sold plots. Regressions on three sub-samples of buyers were performed in order to assess whether different buyers have different attitudes or plans regarding the farmland purchased: a sub-sample including only farmer buyers, a sub-sample including non-farmer individual buyers, and a sub-sample including non-farmer non-individual buyers. Estimations were performed both ignoring and accounting for spatial interactions (model SARAR).

Results indicate that the price of land decreases when buyers are farmers. This may come from the fact that, in such cases, the land will be used for agricultural uses and not for alternative uses for which the expected return may be higher. The environmental zoning regulation considered (namely the nitrate surplus area zoning) increases the price of land. The effect of this zoning regulation is stronger for farmer buyers than other buyers, due to the increased competition for land in order to spread manure. Regarding land transaction regulations, while we had no a priori expectation on the effect, on land price, of the purchaser being the current tenant, we found a significant negative impact. This may reveal the absence of competition on the land market for plots currently farmed by a tenant, who has a priority over other buyers. Contrary to the expectation, we found no significant effect of the pre-emption right of SAFER in the model estimated for the whole sample. However, when estimating the model on the less heterogeneous sub-sample of non-farmer non-individual buyers, we found a significant negative effect of SAFER being the buyer.

While this latter effect was expected, it should also be kept in mind that among the transactions pre-empted by SAFER, not all of them are effectively subjected to a reduced price. SAFER may intervene on the land market by buying land and selling it back at a lower price, but it can also sell it back at the same price but to another buyer. While the first type of intervention aims at limiting price increases, the second intends to limit enlargement of farms that are already large and to favour the settlement of young farmers. In addition, SAFER's role is not confined to pre-empting land that is being exchanged. Before resorting to this extreme case, SAFER firstly tries to solve the issue by mutual agreement. Therefore, a part of SAFER's intervention on the land market in France is not captured in our data (this explains why only 3% of the transactions considered here were subjected to SAFER's pre-emption right).

Estimating the model on different sub-samples depending on the buyers' type enabled to raise evidence of effects which would have been blurred within the full sample, for example the effect of SAFER being the buyer. Separating into the sub-samples also shed light on the factors which are more important for each type of buyer. The results reveal that the price paid by farmer buyers is strongly influenced by the gross margin (which proxies the potential agricultural revenue which can be generated by the purchased land), and by the location in environmental zoning. By contrast, the price paid by non-farmer buyers is more influenced by variables proxying the potential revenue which can be generated by non-agricultural uses of land. This effect is even more pronounced for the sub-sample of non-farmer non-individual buyers, which include SAFER and other public bodies such as administrative councils. This suggests that those buyers are more interested in plots which are located near densely populated and urbanised areas. This is where conflicts may occur and necessitate SAFER's intervention to avoid land speculation, and this is where agricultural land is more often urbanised.

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