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Dynamics of suburban land use change: the importance of quality wine in the Bordeaux region

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The article studies changing land use between 2002 and 2009 in the Greater Bordeaux metropolitan area for land that had previously been used for wine production but was also capable of supporting residential purposes. It aims to analyze the phenomenon of parcel conversion in terms of the speed at which this occurs across a suburban area. The article's originality resides in its development of a spatial breakdown enabling the definition of different sub-regions of quality-wine production. A duration model is tested to ascertain the cumulative effects of the explanatory variables on the likelihood of transition for parcels. With outcomes varying from one trajectory to another, we suggest that there are different spatial dynamics in Bordeaux's suburban wine-producing spaces, depending on the quality and reputation of the vineyard in question.

Between 2000 and 2010, the Aquitaine region (in Southwest France) lost 96,000 hectares of agricultural land at a rate twice as fast as in the rest of the country (Safer, 2012). Affected by population growth hence a greater need for housing—not to mention vineyard destruction incentives and soil erosion—the area covered by vineyards shrank nearly 4.5%. Gironde county, which accounts for more than 75% of the Aquitaine region's wine production area, was the worst hit (Agreste, 2000; 2006).

With suburbs experiencing greater population growth than urban areas overall for some time now, there is increasing pressure to convert exurban farmland (including vineyards) irretrievably to suburbs (Bell, Boyle, & Rubin, 2006). In this paper, we seek to estimate how resistance to the conversion of land use is affected by the presence of high quality vineyards. Specifically, how important is a wine's appellation of origin in slowing land use change locally (Carrion-Flores & Irwin, 2004)? Slowing is a good thing; it preserves land for food production, landscapes, climate effects, and other economics functions. Sustainable land management requires preservation of soil functionality and agricultural potential.

The experience of Bordeaux's exurban vineyards is helpful in analyzing the importance of quality wine production. See Map 1. More than 50 *appellations d'origine contrôlée* (AOC) are found in the vicinity. The great diversity of quality in wine has fostered a hierarchy of AOCs with corresponding differences in wine prices. Land prices also reflect this quality hierarchy, albeit with some variation (Pérès, 2007).

The traditional hedonic price approach to land use change—based on competition in the land market—typically does not incorporate temporal dynamics. Temporal dynamics is important because agricultural land consumption (by urbanization) only grows; it is an irreversible phenomena. In this paper, a duration (hazard) model is used to explain the timing of conversion of parcels (i.e., vineyards) to residential use. The effects of the explanatory variables on the likelihood of this transition are estimated. We test the hypothesis that vineyards that produce "prestige" AOC wines—those characterized by high land prices—are more resistant to urbanization: that is, slower to convert. The AOC label is a resistance factor because it generates higher prices; the landowner has an interest in keeping his parcels if the AOC vineyard offers him a higher income.

To summarize, we study the speed with which land use change spreads across Bordeaux's vineyard parcels in the exurbs, with a particular focus on AOC status. The article is structured as follows. The first section starts with individual decision-making processes relating to land use change. What factors determine conversion within an exurban zone? We place particular emphasis on distinctions among parcels based on their capacity to produce wine. This is followed by a presentation of the data and method used to construct a spatial typology of Bordeaux AOC wines and then to model the speed of conversion away from wine production within each subregion. Finally, there is a presentation and discussion of findings, highlighting top AOC wines' strong and differentiated resistance plus variations in resistance dynamics translating each group of high quality AOCs' geographic breakdown.

Theory

The body of economic literature on land use change is vast: dating back to von Thünen and Alonso. Much of this literature is built around the idea that land use decisions occur for one reason: to maximize net returns from the use of land. Landowners are thought to make choices—between, for instance, converting a parcel to residential use or keeping it in its current state—driven by profit maximization. For Munneke (2005), the timing of conversion is related to the land price gain associated with a conversion in

Map 1. Study area, showing number of wine transactions by class of AOC from 2002 to 2009.

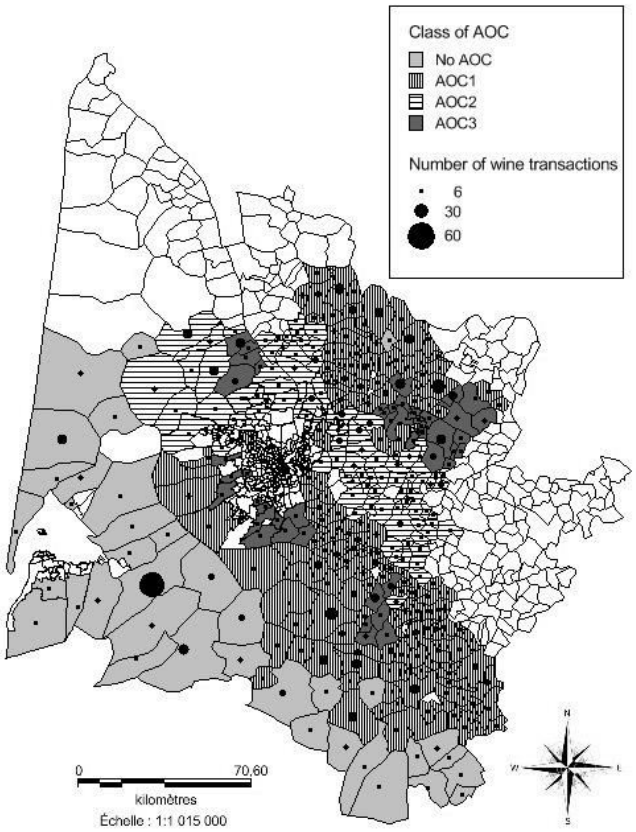

Table 1. Definitions of explanatory variables.

	Variable	*Definition*	*Average*	*Standard deviation*
Town level	Dist	Distance in meters from town to city center of Bordeaux	1619.012	1510.327
	POP_AGR	Agricultural population growth rate, 1999-2006 (INSEE)	-0.252	0.552
	POP	Population growth rate, 1999-2006 (INSEE)	0.123	0.125
	REV	Town's median income growth rate, 1999-2006 (INSEE)	0.232	0.066
Parcel level	Area	Area of parcel being sold, in ares (SAFER)	3.727	0.726
	BAT	Dichotomous variable attesting to presence of a building on the land parcel, 1 if building present, 0 otherwise (SAFER)	0.098	0.297
	LOC	Dichotomous variable characterizing rental situation, equal to 1 if parcel was occupied, 0 otherwise.	0.218	0.413
	AC_AGR	Dichotomous variable: 1 if buyer was a farmer, 0 otherwise (SAFER)	0.658	0.474
	AOC_1	Dichotomous variable attesting to AOC designation, reflecting quality and reputation, equal to 1 if parcel was situated in an AOC_X, 0 otherwise (CIVB)	0.506	0.500
	AOC_2		0.236	0.425
	AOC_3		0.124	0.329

Source: Bordeaux sample assembled by authors: 2,357 vineyard parcels.

the use of a parcel: expressed by the difference between the stream of future rents in its current use and the maximum stream of future rents that can be extracted from an alternative use. This motive supposedly prevails irrespective of the kind of choice being made (e.g., agricultural versus non-agricultural use or residential versus non-developed use).

This literature typically classifies determinants of land use change into two main categories. The first category includes the specific qualities (main characteristics) of each parcel: natural, geographic, topographic or physical – based, for instance, on its access to network externalities (Cavailhès *et al*., 2003; Fleischer & Tsur, 2009; Irwin, Bell, & Geoghegan, 2003; Segerson, Plantinga, & Irwin, 2005). The second highlights the particular locational context: to account for local spatial

Table 2. Definition of variables explaining wine quality.

Variable	*Definition*
Tier 1 AOC	Sales price for one hectolitre of wine, ranging between €70 and €110
Tier 2 AOC	Sales price for one hectolitre of wine, ranging between €100 and €150
Tier 3 AOC	Sales price for one hectolitre of wine, above €150

Table 3. Appellations' breakdown by sub-region.

Appellation name	*Geographic location*
Medoc, Pauillac, Haut Medoc, Listrac, Saint Estephe, Moulis, Saint Julien, Margaux	Northeast
Cotes de Bourg, Cotes de Blaye	North
Loupiac, Sauternes	Southeast
Liquoreux Rive Droite, Graves Rouges, Premieres Cotes do Bordeaux, Graves Blancs , Pessac Leognan	South
Pomerol, Canon Fronsac, Cotes de Castillon, Cotes do Francs, Fronsac, Saint Emilion/Satellites, Lalande de Pomerol, Graves de Vayres	East
Bordeaux White, Bordeaux Red	Bordeaux

externalities. Most studies find that location is important. These effects generally stem from the presence of transportation costs (Alonso, 1964; Muth, 1969) and the aforementioned spatial externalities (Irwin, 2002).

In short, the net profit expected from converting the use of a parcels are a function of parcel attributes that influence their conversion (Nelson & Hellerstein, 1997). Empirical studies have explained the value of a parcel depends on the market's evaluation of its various characteristics (Geoghegan, 2002; Munneke, 2005).

Land use change explanations can be analyzed using a range of spatial scales. Studies in this area are generally grouped into two categories.

The first examines spatially explicit models using data that is available on a very small spatial scale nowadays because of the way that GIS (Geographic Information Systems) enables geo-localization (Wu, 2002; Wu & Webster, 2000).

Hence a second category of studies that focus more specifically on models aimed at explaining economic conversion process. Studies of this kind mobilize a range of methods, including hedonic prices (Garrod, 1994; Powe, Garrod, & Willis, 1995) and duration or logit models, to ascertain the main determinants of parcel transactions (McMillen, 1989; Claassen & Tegene, 1999; Ding, 2001; Irwin & Bockstael, 2002; Carrion-Flore & Irwin, 2004; Bell *et al.*, 2006). The sum total of this research effort comprises a shared theoretical foundation, with the question of parcels' changing use being studied via traditional bid rent models and after taking into consideration different spatial variables, including roads, rivers, coastline access, parcel location, the main characteristics relating to the local metropolitan area or distance from the road network. The present article relies on this shared theoretical framework, which helps to elucidate the determinants of wine-producing land's conversion to residential use.[1] More specifically, it aims to identify the key role that the appellation of origin (AOC) classification plays in resisting urbanization (Cavailhès & Richard, 1992; Combris, Lecocq, & Vissier, 1997) in the specific instance of the Greater Bordeaux metropolitan area.

Consider a simple land allocation decision. A landowner has a fixed amount of land, *A*, to allocate between two alternative uses (a_1 and a_2 with $A = a_1 + a_2$, for agricultural land and non-agricultural land for example). Each use generates a private net return, which we can denote R_1 and R_2. The basic land allocation problem is to maximize the total return from the land, subject to the constraint that the sum of land in the 2 uses must equal the total amount of the available ($R = R_1 + R_2$). This problem can be written as: Max $R = R_1 + R_2$ subject to $a_1 + a_2 = A$, $0 \leq a_1 \leq A$ and $0 \leq a_2 \leq A$. We can consider that the net returns are linear in the amount of land allocated to the two uses: $R_1 = r_1 a_1$ and $R_2 = r_2 a_2$.

With linear returns, all of the land should be put into the use with the higher return. So, the solution is to set $a_1 = A$ and $a_2 = 0$ if $r_1 > r_2$ (and $a_2 = A$ and $a_1 = 0$ otherwise). If $r_1 = r_2$ the landowner should be indifferent between putting the acre into use 1 or use 2.

But net returns from alternative land uses can also vary over time. Temporal variation in returns can stem from exogenous changes factors that affect returns. The link between present decisions and future returns usually stems from several sources: the irreversibility effect (the decision to convert land from a natural state to a developed use for example), the stock effects (the decision affects the stock of a variable -quality- that in turn affects future land use returns). Then the optimal decision is based on the solution to a dynamic land allocation problem.

Investigations looking at how long a particular use lasts are relatively recent and largely cover suburban American spaces (Hite *et al.*, 2000; Nickerson, 1999). In one recent text, Bell *et al.* (2006) provided an exhaustive and detailed literature review covering the conversion of land to residential use. Irwin & Bockstael (2002) analyzes changes in urbanization by looking at the speed at which farmland was being converted to residential use, relying for this on a duration model enabling them to study the speed of par-

Table 4 Duration model findings across appellations' spatial typology

Variables		*Model I* Model without AOC typology or zone Coeff.	Std.Err.	t-ratio	*Model II* Model wiith AOC typology Coeff.	Std.Err.	t-ratio	*Model III* Model with AOC typology and zone Coeff.	Std.Err.	t-ratio
	Constant	2.264***	0.562	40.255	0.705***	0.079	40.08	2.283***	0,568	40,21
Parcel characteristics section	AC_AGR	-0.384***	0.02	-19.141	-0.717***	0.035	-20.41	-0.384***	0,02	-19,141
	LOC	-0.042**	0.02	-2.086	-0.101**	0.037	-2.71	-0.042**	0,02	-2,086
	BAT	0.027***	0.031	3.856	0.123***	0.04	3.1	0.027***	0,031	3,856
	Area	-0.040***	0.013	-3.022	-0.031***	0.019	-2.62	-0.04***	0,013	-3,022
	Dist	-1.64e^{-5}***	6.37E-06	-2.788	-1.27 e^{-5}***	6.72E-06	-3.03	-1.04 e^{-5}***	4,93E-06	-2,788
	TXCAGR	1.62E-05	4.76E-05	0.34	0.003	0.024	0.14	1.95E-05	8,93E-05	0,75
	TXCRP	-1.22E-04	0.001	-0.395	-0.071	0.114	-0.62	-1.53E-04	0,001	-0,395
	TXCREV	-1.12E-04	6.82E-05	-1.575	-1.13E-04	6.27E-05	1.09	-1.89E-04	2,88E-05	-1,575
Resistance section	AOC	-0.863***	0.032	-2.477						
	- AOC1				0.027	0.032	0.85	0.016	0,331	0,509
	- AOC2				-0.064*	0.044	-2.06	-0.138*	0,032	-2,44
	- AOC3				-0.066***	0.045	-4.46			
	- EAST							-0.061**	0,031	-2,13
	- NW							-0.012**	0,036	-2,333
	- NORTH							-0.032**	0,041	-2,767
	- SE							-0.033**	0,037	-2,893
	- SOUTH							-0.037***	0,041	-3,908
N			2,357			2,357			2,357	
Log Likelihood			-1072,23			-1268.605			-1373.644	
Iterations completed			19			21			25	

Notes

The exponential form was used here since it seemed more appropriate than linear distance (problem of multicollinearity with other variables), in the absence of transformation, for assessing how town centre accessibility impacts on the organization of space.

The parcels' area affected the characteristics expressed in a logarithmic form, as per usual specifications reflecting the non-linear nature of the relationship between area and land price, and translating the consistency of the price/area elasticity for each segment (Colwell and Munneke, 1997; Goffette-Nagot, 2009).

Coefficient: * p<.10; ** p<.05; *** p<.01.

cel change across suburban spaces in the US state of Maryland. That paper concludes that the conversion rate fell by 3% for every 1% increase in parcel distance from Washington DC. Another study that use duration model is Irwin & Bockstael (2002) which analyzes the rate of agricultural land conversion into residential use in Maryland: see also Irwin, Bell, & Geoghegan (2003).

Study area

We use the Greater Bordeaux metropolitan area to pinpoint vineyard parcel sales.

Method

Economic models (such as discrete choice models) that monitor land use changes focus explicitly on explaining such changes at a certain moment in time, instead of on why the land has been allocated to one or the other use. One of these models' limitations is their lack of temporal dynamism (De Pinto & Nelson, 2007). The conversion is dynamic in that, at the time data are collected, not all the dynamic forces and interactions responsible for land use choices have played out. As responses to these changes are not instantaneous, observations at a time close to when the policy changes are implemented or infrastructure investment is completed might not reflect the eventual equilibrium. Furthermore, the costs associated with the process of change from one land use to another affect the speed of change, which may be faster for some conversions than others. Ignoring the time dimension also corresponds to ignoring the possible option value of certain choices, learning processes and sunk costs. All these factors imply that the expected profit needed to induce land use conversion is likely to be significantly higher than the profit derived from the current use. The most interesting question at this level often pertains to when a parcel is converted rather than whether this actually happens. Duration models explicitly incorporate the date when a qualitative change occurs from one state to another. They are therefore a good way of capturing explanatory variables' cumulative effects on the probability of transition. This is a good thing in the sense duration models help capture the cumulative effects of explanatory variables on the probability of transition

Duration model analyses of land use changes assume an introduction of concepts such as survival and hazard functions. Take a continuous non-negative random variable *T* as representing the "waiting time" from t_o until the occurrence of an event.

Table 5. Survival rate within the AOC-3 sub-region.

Survival rate	*Total*	*AOC-3*	*East*	*NW*	*SE*	*South*	*Bordeaux*
25%	7.12	7.59	7.46	7.13	7.46	7.32	7.38
50%	5.48	5.75	5.53	5.5	5.67	5.52	5.22
75%	4.21	4.36	4.1	4.23	4.31	4.17	4.25
95%	2.89	2.93	2.67	2.91	2.9	2.78	2.95

Considering *t* an outcome of *T*, the survival function *S(t)* here is the probability of a parcel sold to remain a vineyard (or not be converted to urban) to time t:

$$S(t) = Pr\{T \geq t\}, t \geq 0$$

The cumulative distribution function *F(t)* is the conversion probability before time *t*:

$$F(t) = Pr\{T < t\} = 1 - S(t)$$

The probability density *f* is a function f(t) ≥ 0, such that for all t≥ 0,

$$F(t) = \int_0^t f(s)ds$$

If the distribution function has a derivative at the point *t* then

$$f(t) = \lim_{dt \to 0} \frac{Pr\{t \leq T < t + dt\}}{dt}$$
$$= F'(t) = -S'(t)$$

For fixed *t*, the probability density function characterizes the probability of a parcel sold to be converted into a small time interval after time *t*.

The instantaneous risk, also called "hazard rate" is defined as:

$$\lambda(t) = \lim_{dt \to 0} \frac{\Pr\{t < T \leq t + dt | T > t\}}{dt} = \frac{f(t)}{S(t)}$$

For fixed t, $\lambda(t)$ characterizes the probability of a parcel sold to be converted into a small time interval after time t, conditional on having survived to time t.

This measures the risk of knowing an event at the end of a time period *t*, something that was previously unknown. Applied to change episodes, the hazard function evaluates a property's exit rate away from wine production after a period *t* when it was used for such purposes. Symmetrically, when applied to episodes characterized by an absence of change, the model measures the risk of undertaking a conversion after spending *t* time outside of urban use.

The equation of the hazard function is :

$h(t) = (p/t)\Phi[p\ln(\lambda t))$

where $\lambda_{ø}(t)$ is the hazard rate for a time t supposed a continuous duration. We estimate the model using maximum likelihood. We seek to determine the time (in month) a vineyard parcel lasts before it is converted to urban use.

The model can be interpreted as a continuous hazard model that has been incompletely observed because it is subject to right and left censoring, without any restrictions as regards the form of the basic hazard function.[2] Several estimates were needed to determine the hazard function.

The lognormal distribution is mainly used to model situations where the conversion risk of the parcel is decreasing from the date of sale. So we use the base hazard function in lognormal format, with the log probability being the lowest.

Above, AC_AGR is a buyer characteristic. It provides information on the transaction nature such as area or the existence of a build... That is why we introduce it in the duration model: see Dachary-Bernard et al (2011)

Data

We use the Greater Bordeaux metropolitan area to examine parcel sales. This is relevant precisely because it highlights which spatial issues are at stake when parcels are sold and converted to residential use, rather than individual land use change decisions *per se*.

All Gironde county parcels transacted between January 2002 and December 2009 were identified and considered. The data indicated which interval contained the duration of resistance measured in units of one month. Thus, the months when the conversion happened became the date of the event. Censoring occurred in 2009 but also in 2002. An event was defined as the date at which the parcel was purchased with the intent to replace wine production by residential use.

The model was estimated based on the number of transactions involving parcels converted to residential use in Gironde county from January 2002 to December 2009. We extracted real estate transaction data from the SAFER (*Société d'Aménage-ment Foncier and d'Établissements Rural)* inventory, which compiles information on farmland sales to determine if they are under- or over-valued. The data was compiled at the moment the parcels were sold. It included the size (in acres) and post-sale use (wine production or residential).[3] All in all, out of the 2,357 vineyard parcels across the county, 644 of the sales between 2002 and 2009 involved conversion to residential use.[4] Additional variables describe the nature of the transactions (presence and type of building, buyer characteristics).

The Bordeaux vineyard as a whole includes more than 50 appellations split into four families of red wines and two families of white wines.[5]

As noted in studies by Laporte (2000), the system partially mitigates the informational asymmetry that exists between producers and consumers with regards to quality. By so doing, it underpins wine pricing. Still, significant variability in quality benchmarks means that distinctions and hierarchizations continue to be made within each AOC category, materialising in price differences that largely reflect the extent to which each AOC benefits from widespread recognition. At the same time, land price levels are in line with quality rankings, exhibiting varying levels of resistance to uneven urbanization pressures (Pérès, 2007). Thus, "prestigious" appellations characterized by high land prices are more resistant, possibly attesting to the

Table 6. Comparisons of urbanization and wine production forces.

Region	*Average waiting time before conversion (in months)*	*Slope of hazard function*
East	44.3	0.028
Northeast	40.5	0.035
Southeast	40.73	0.020
South	41.7	0.023
Bordeaux	38.69	0.021
Sum total for AOC_{-3}	40.44	0.022
Sum total for urban district	38.9	0.006

AOC classification's major role as a factor of resilience.

Also included were the socio-economic characteristics of the towns where the parcels were being sold (median income, population growth). The data came from INSEE (French National Statistics Office) files, and more specifically from the town population census taken between 1999 and 2006. This justifies the idea that the data could be considered identical for all of the parcels located within one and the same town. To highlight the different ways in which property-related pressures were being felt across Gironde county, the analysis covered the dominant forms of land use over the period 2002-2009, as per the Corine Land Cover model.[6] These parcel-based spatial characteristics, analysing dominant forms of land use, also provided information about parcel distance to the closest urban border, how long it took to penetrate to the heart of the closest urban zone, etc. Lastly, vineyard quality indicators' role not only as signals but above all as factors of resistance to urbanization was accounted for by noting a particular parcel associating with an AOC designation. Table 1 presents all of the explanatory variables chosen for this study.

Analysis and interpretation

Resistance analysis, which takes temporal factors into account, assumes at least some reliance on duration econometric models.[7] Findings from the present analysis are given in Table 4. We make three basic findings from this empirical analysis.

The first finding is the importance of parcel characteristics. Three out of four variables were significant at the 1% level. "Small operations" are generally associated with a fragmented parcel structure (Charvet & Rouyres, 1994). Small operations are conducive to uneven suburbanization, hence to urban sprawl. The pace of suburbanization is lower for larger parcels. This result is unsurprising insofar as it was those parcels that were smallest in size - and often owned by operators exercising a number of different activities, or else by cooperative members - that were the most affected by sprawl (Archer, 1973; Slak, 2000). The size of the parcel clearly appears at this level as an element of resistance to urban sprawl. At the same time, the marginal effects of parcel area remain minimal. The influence of parcel status—rented or not—are basically the same. A parcel that was rented seems to have produced greater benefits than when it was sold for residential purposes (Carrion-Flores & Irwin, 2004). In other words, urbanization pressures seem to have reduced the value of a parcel at the moment of its sale in comparison with its transformation to residential use. It is important, however, to note that the effects of parcel status (whether it was rented or not) were only significant to a threshold of 5%. In terms of characteristics relating to whether the parcel being transformed to residential use had buildings, the estimated coefficients were both positive and significant. A parcel with a building was much more likely to be converted to residential use.[8] Since the marginal effects decreased with distance, this shows how urbanization pressures play a greater role in suburban spaces, one that decreases with distance, thereby describing the urban sprawl process. Lastly, the buyer's profession had a not insignificant effect on model outcomes since the fact that a buyer was a farmer sharply reduced the likelihood that the parcel being sold would be converted – in line with research done by Cavailhès, Hilal, & Wavresky (2011) or Lefebvre & Rouquette (2011).

The second finding is the relative lack of influence of the urbanization pressure variables on the speed of conversion. This is because neither population growth variables (TXCRPOP and TXCAGR) nor income growth variables affect the hazard rate. The income variable's ambiguity seems to have been confirmed here since it was not significant (Alig, Kline, & Lichtenstein, 2004; Georghegan, 2002; Brueckner, Thisse, & Zenou, 1999). It remains that the (DIST) variable clearly had the greatest effect on explanations of change in land use. The speed of conversion in parcel land use therefore depends to only a small extent on population suburbanization factors. On the other hand, it was closely linked to distance.

The final finding is importance of AOC resistance. In the initial modeling where all of the transactions included a modicum of discrimination as regards wine quality, resistance continued to be largely predicated on the appellations' quality and reputation (Corade & Del'homme, 2005). As aforementioned, a significant hierarchy exists between AOCs, one that is neutral in terms of a vineyard's resistance to urbanization pressures. To flesh out this initial funding, a second stage was conducted, based on the choice of constructing an AOC typology around appellations' hierarchy expressed in terms of wines' per-hectolitre price (Pérès, 2007). In the end, three AOC levels were used (tiers 1, 2 and 3) to model the intrinsic hierarchy: see Table 2. The typology developed in this way strongly added to the significance of the appellation effect, with the student-T value rising from -2.477 for the AOC variable to -4.46 for AOC_{-3} This construction shows that being a tier 3 AOC (the ones with the best reputation) significantly diminishes both the risk of a change in parcel use and also its hazard rate. This finding bolsters the hypothesis that AOC appellations have been sending weakening signals across the Bor-

deaux region. Indeed, by creating an official quality designation (Economie Rurale, 2000) recognized by most if not all of the Bordeaux wine industry, the banalization of the AOC designation might undermine its visibility and protective effects (Jullien & Smith, 2004). The surfeit of appellations, quality doubts and excess communications about mediocre products could explain certain serious weaknesses afflicting the Bordeaux model (INRA, 2004). "By having too many branch-level quality specifications, it is easy to forget why they even exist" (Jullien & Smith, 2004). Note, however, that in the towns closest to Bordeaux itself, the vineyard has contracted to such an extent that there is little left asides from a very few intra-urban wine-producing spaces, which may be very valuable and classified as AOC_{-3} but have no room to grow. For a better explanation of AOC-related findings, it could be useful to evaluate very high quality AOC_{-3} categories. Hence our sub-regional breakdown, which amends an idea first forward by Wiel (2001; 2003). Introducing this particular kind of zone structured helps to verify the influence of spatial trajectories on vineyard resistance. This zoning is designed to follow the most important transport infrastructure of the geographical area. It is a sectorization that matches the leading appellations found in the Greater Bordeaux metropolitan area.

The parcels are grouped here according to whether they are part of a particular territorial zone: see Table 4.

In Table 4, the findings of different models reveal a strikingly positive dependency on duration. A parcel that was sold had an especially high likelihood of being converted (or of abandoning wine resistance) the longer the waiting time. The average survival rate in the AOC_{-3} zone was 5.75 versus 5.48 for the whole of the Greater Bordeaux metropolitan area (Table 5).

In other words, the fact of operating out of a AOC_{-3} zone strongly affected the probability that the parcel would maintain its wine production function and therefore lessened its likelihood of being converted to residential use, all things remaining equal. Regarding temporal conversion trajectories within the AOC_{-3} sub-region, incorporating the time factor shows the process's strength in each of the study zones. Note that comparisons between the two forces in presence (wine production and urbanization) can also be done through analyses comparing the slope of each zone's hazard functions (Table 6).

Thus, although being embedded in a highly reputed appellation increased the average pre-conversion waiting time by more than 1½ months compared to not being part of this category, differences can be observed between appellations belonging to one and the same group. In the Bordeaux zone, for instance, characterized as it was by strong urbanization pressures that weakened its wine production resistance, average waiting times until conversion were smaller than for the whole of the territory under study (38 instead of 39 months). On the other hand, the East, South and South-eastern Zones, comprised of top reputation vineyards such as Pomerol, Loupiac or Pessac-Léognan, seemed to benefit from a relatively strong wine production-related capacity for resisting the advance of urbanization, with a resistance number that rose by 9.5%.

Conclusion

We have analyzed changes in the use of vineyard parcels around Bordeaux by modeling dynamic spatial trajectories with a duration model. In line with previous research by Pérès (2007), Bordeaux wines were broken down into an AOC typology their reflecting their reputation and quality. A sub-regional breakdown translating the differentiation in spatial dynamics was then constructed around this typology. This was followed by a duration model providing information on the range of variables explaining the land use change process and its speed. These explanatory variables were linked to the profile of the parcels, their social environment (i.e. proximity to an urban area and urbanization pressures) and the quality of the wine being produced.

The main findings show that the conversion of parcels sold between 2002 and 2009 was influenced by two principal factors that might have had a complementary effect. First, the parcels' inherent characteristics had a significant effect on the land use change process. Secondly, although one of the findings is that AOC-based quality and reputation have a positive effect on parcels' resistance, the hierarchy within the AOCs confirms that the signals being sent across the Bordeaux region are weakening. It would appear that being part of AOC_{-3} was beneficial, since the speed at which parcels were being converted fell by nearly 5%. The other two AOC groups did not have any significant impact, however. Conversely, within AOC_{-3} there is significant spatial asymmetry between different resistance processes. The results of comparing wine production and urbanization forces show the different dynamics at work in the territories in question. Further research into urban planning policies and current legislation could, for instance, help to anticipate land use conflicts in particularly fragile territories by offering efficient protection for the particular uses that are under threat, in comparison with spaces where their preservation is socially preferred.

The approach suggested here also merits further study, with space being included as a factor in duration models. Integrating certain temporal dimensions into land use change evaluations should help to account for phenomena associated with land use change expectations. Viewing space as a process modeling factor offers other elements of reflection as well (Holloway, Lacombe, & LeSage, 2007). In particular, accounting for spatial self-correlation might highlight potential spillover effects relating to the formation of property prices.

References

Agreste. 2006. Panorama de la Viticulture, *Agreste Cahier Viticulture 1*, Janvier.

Agreste. 2000. 100 000 hectares de terres agricoles en moins chaque année – Les paysages agricoles en

repli devant les landes et les villes, *Agreste Primeur La statistique agricole, 76*.

Alig, RJ, Kline, JD, & Lichtenstein, M. 2004. Urbanization on the US landscape: looking ahead in the 21st century. *Landscape and Urban Planning 69(2),* 219-234.

Alonso, W. 1964. *Location and land use: toward a general theory of land rent*, Cambridge MA: Harvard University Press.

Archer, RW. 1973. Land speculation and scattered development: failures in the urban fringe market. *Urban Studies 10(3),* 367-372.

Bell, KB, Boyle, KJ, & Rubin, J. 2006. *Economics of Rural Land-Use Change*. Aldershott UK: Ashgate.

Brueckner, JK, Thisse, J-F, & Zenou, Y. 1999. Why is central Paris rich and downtown Detroit poor? An amenity-based theory, *European Economic Review 43(1),* 91-107.

Carrion-Flores, C, & Irwin, EG. 2004, Determinants of residential land use conversion and sprawl at the rural-urban fringe, *American Journal of Agriculture Economics 86(4),* 889-904.

Cavailhès, J, Hilal, M, & Wavresky, P. 2011. L'influence urbaine sur les prix des terres agricoles et ses conséquencezs pour l'agriculture, *Économie et Statistique 444–445*, 99-125.

Cavailhès, J, *et al.* 2003. La ville périurbaine, *Revue Economique 54(1),* 5-24.

Cavailhès, J, & Richard, A. 1992. Marché foncier et prix des terres agricoles. *INRA Sciences Sociales, Recherches en économie et sociologie rurale 5.*

Charvet, JP, & Rouyres, T. 1994. 9000 agriculteurs face à une agglomération de 10 millions d'habitants: les chances de résistance de l'agriculture d'Ile de France. *Cahiers Nantais 43,* 147-172.

Claassen, R, & Tegene, A. 1999. Agricultural land use choice: a discrete choice approach. *Agricultural and Resource Economics Review 28*, 26-36.

Combris, P, Lecocq, S, & Vissier, M. 1997. Estimation of a hedonic price equation for Bordeaux wine: does quality matter? *Economic Journal 107,* 390-402.

Corade, N, & Del'homme, B. 2005. L'efficacité de la viticulture sous AOC: le marché contre le territoire ? Les perceptions de viticulteurs Médocains et Bergeracois, *Oenometrics XII, Colloque de la VDQS, Macarata*, 27-28 mai.

Dachary-Bernard, J, et al. 2011. L'impact de la littoralisation sur les marchés fonciers : Une approche comparative des côtes basque et charentaise. *Économie et Statistique 444–445*, 127-154

De Pinto, A, & Nelson, GC. 2007. Modelling deforestation and land-use change: sparse data environments. *Journal of Agricultural Economics 58(3),* 502-516.

Ding, C. 2001. An empirical model of urban spatial development patterns, *Review of Urban and Regional Development Studies 13(3),* 123-138,

Economie Rurale. 2000, Les signes officiels de qualité. Efficacité, politique et gouvernance. *Economie Rurale 258*.

Fleischer, A, & Tsur, Y. 2009. The amenity value of agricultural landscape and rural–urban land allocation, *Journal of Agricultural Economics 60(1),* 132-153.

Garrod, GD. 1994. Using the hedonic pricing model to value landscape features. *Landscape Research 19 (1),* 26-28.

Geoghegan, J. 2002. The value of open spaces in residential land use. *Land Use Policy 19(1),* 91-98.

Hite, D, *et al.* 2000. Competing risks in the suburbanization of agricultural land, *Proceedings of the 2000 Annual Meeting of the American Association of Agricultural Economists*, Tampa, FL.

Holloway, G, Lacombe, D, & LeSage, JP. 2007, Spatial econometric issues for bio-economic and land-use modelling. *Journal of Agricultural Economics 58(3),* 549-588.

INRA. 2004. Quel avenir pour le modèle d'Appellation d'Origine Contrôlée dans le secteur viticole ? *Dossier de Presse INRA.*

Irwin, EG. 2002. The effects of open space on residential property values. *Land Economics 78(4)*, 465-480.

Irwin, EG, Bell, KP, & Geoghegan, J. 2003. Modelling and managing urban growth at the rural-urban fringe: a parcel-level model of residential land use change. *Agricultural and Resource Economics Review 32(1),* 83-102.

Irwin, EG, & Bockstael, NE. 2002. Interacting agents, spatial externalities and the evolution of residential land use patterns. *Journal of Economic Geography 2(1),* 31-54.

Jullien, B, & Smith, A. 2004. Comment analyser les indicateurs géographiques protégées sans préjuger de leurs singularités? Cahiers du GRES 7.

Laporte, C. 2000. *Système d'information sur la qualité et profit: le cas des vins d'appellation d'origine contrôlée de Bourgogne*, Thèse d'économie, Dijon, Université de Bourgogne.

Lefebvre, L, & Rouquette, C. 2011. Les prix du foncier agricole sous la pression de l'urbanisation. *Économie et Statistique 444(1),* 155-180

McMillen, DP. 1989. An empirical model of urban fringe land use. *Land Economics 65*, 138-145.

Munneke, HJ. 2005. Dynamics of the urban zoning structure: an empirical investigation of zoning change. *Journal of Urban Economics 58(3),* 455-473.

Muth, R. 1969. *Cities and Housing*. Chicago IL: University of Chicago Press.

Nelson, G, & Hellerstein, D. 1997. Do roads cause deforestation? Using satellite images in econometric analysis of land use. *American Journal of Agricultural Economics 79*, 80-88.

Nickerson, C. 1999. *Characterising Participation in Farmland Preservation Programs. Working paper 99-17*. Department of Agricultural and Resource Economics, University of Maryland.

Pérès, S., 2007, La vigne et la ville: Forme urbaine et usage des sols, Thèse pour le doctorat ès Sciences Economiques, Université de Bordeaux.

Pérès, S, & Gaussier, N. 2010. La conversion de parcelles viticoles en usage résidentiel: le cas de l'aire urbaine de Bordeaux. *Revue Canadienne de Science Régionale/Canadian Journal of Regional Science*, 33, 123-136.

Powe, NA, Garrod, GD, & Willis, KG. 1995. Valuation of urban amenities using an hedonic price model. *Journal of Property Research 12(2),* 137-147.

Safer. 2012. *Le prix des terres - Analyse des marchés ruraux 2011*. mai 2012.

Segerson, K, Plantinga, AJ, & Irwin, EG. 2005. Theoretical background. Chapter 6 in Bell, KP *et al* (eds.), *Economics of Rural Land-Use Change*. Aldershott UK: Ashgate. 79-111.

Slak, MF. 2000. Vers une modélisation du mitage périurbanisation et agriculture. *Etudes Foncières 85*, 33-38.

Wiel, M. 2003. Quelle place donner à la maîtrise de la vitesse automobile en ville ? *XXXIXème Colloque de l'ASRDLF*, Lyon, 1-3 Septembre 2003.

Wiel, M. 2001. *Ville et automobile*. Paris FR: Descartes & Cie.

Wu, F. 2002. Calibration of stochastic cellular automata: the application

to rural-urban land conversions. *International Journal of Geographic Information Science 16(8)*, 795-818.

Wu, F, & Webster, CJ. 2000. Simulating artificial cities in a GIS environment: urban growth under alternative regulation regimes. *International Journal of Geographical Information Science 14(7)*, 625-648.

[1] The basic model of residential land use is adapted from Alonso (1964), Muth (1969), and Mills (1972). Determinants of land use change are described in Segerson, Plantinga, & Irwin (2005).The maximization program is based on revenues, transportation costs (thus distance), and density.

[2] An episode is considered to be censored to the right when an event had not yet happened the last time an observation was made. Conversely, an episode is considered to be censored to the left when the entry date is unknown. Since the data used here is restricted to 2002-2009, nothing is known about the vineyard's ex-ante and ex-post situations.

[3] The data of land development companies and rural settlement (Safer) come from statements intentions to dispose (DIA) forwarded by the Safer notaries and sales by the last. Under the Rural Code and under the preemptive right of the Safer, notaries are required to send projects notifications sales covering all the relative market agricultural and natural areas. All parcels which are notified by the Safer therefore have in common a agricultural or natural vocation, whether potential or real. These data correspond to parcels sales (more than one hectare) for which several characteristics are indicated: average price, buyer's and seller characteristics, etc. These transactions are analyzed using a market segmentation. The main criteria are the nature of cadastral parcels, their destination, size, and nature of sellers and acquirers. So, at the time of sale we exactly know what the parcel will become (and the purchaser can't change his mind because of French public policy).

[4] No property sold more than once during this period.

[5] The Bordeaux vineyard (Gironde County) is bigger than Bordeaux Metropolitan area.

[6] The *Corine Land Cover* geographic database, which is part of a European environmental information coordination program called *Corine*, is overseen by the European Environmental Agency. It is a vector database covering the biophysical use of land, broken down into 44 headings established through an interpretation of satellite images. The version used in the present article came from 2006 and relied on a 25 hectare descriptive threshold for land use data and a 5 hectare threshold for land use change data.

[7] Several estimates were needed to implement this determination. These included a comparison of different function forms, leading in turn to consideration of a lognormal model, one where the log probability was the lowest.

[8] A parcel with a building was much more likely to be converted to residential use because the existence of a build (a house and so on) captures the impact of a previous occupation on the probability of ultimate urban destination. The presence of urbanization on a parcel causes a future urbanization.