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Option values in the market for periurban developable land

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Abstract

We study option values in the developable land market in French periurban and rural areas. We introduce into an econometric model both the classical option value, resulting from short-run volatility of the land price ('market risk') and a long-run option value resulting from uncertainty about demographic change in a spatial belt around a transaction ('population risk'): the price of waiting for more information about migrations when population is fluctuating turns into a second option value. Short-run option values are introduced from the classical approach of a Brownian movement with drift (Dixit and Pindyck, 1994; cf. discussion in Cunningham, 2006), in the form of the observed variability of residential land prices during the preceding months. Long-run option values depend on population change in neighbouring communes. The findings show that both option values exist and are significant. First, in the French department of the Nord, when the standard deviation of the price of developable plots during the previous six quarters rises by a standard deviation, the land price increases by 7.4% during the downturn period of the real estate cycle (1989–1997) and by 15.3% during the upturn period (1998–2002). Second, prices rise significantly with population volatility. In the Nord, during the upturn period, an increase of one standard deviation of the standard deviation of the variation in population between 1982 and 1999 entails a 6% increase in the developable land price.

1. Introduction

Over the last 40 years or so France has experienced a periurbanization movement (cf. Figure 1) comparable to urban sprawl or suburbanization in the US and more generally to the migration towards the countryside at varying distances from big cities that has been going on in most developed countries. The migration balance of periurban areas[1] has been +0.6 to +1.7% per annum depending on the period and for urban areas population this balance has verged on + 1% per annum since 1999. By contrast, migration balance has been negative for urban centres since 1975.

These demographic movements are reflected by the conversion of farmland, woodland and undeveloped land to urban land uses, whether residential or not (e.g. industrial and tertiary activities, communication networks) (cf. Figure 2). Developed land has been growing faster than the population (+2 to +3% per year) and communication networks have been growing by about 1% per year. These are irreversible conversions taking anywhere from several months

[1] Periurban areas are defined as having non-contiguous built areas (residential land alternates with farmland and woodland) and more than 40% of the residents commute to urban areas, where built areas are continuous and there are more than 5000 jobs.

to several years between the time the decision is made and the time the development (housing or offices, etc.) is completed. This engenders uncertainty as to the selling price at the end of this period. It may therefore be preferable, before implementing the irreversible decision to build, to wait until the market has provided enough information for the risk of selling at a loss to be low enough. If the decision is postponed, some flexibility is maintained, allowing the land owner to build at what is thought the most opportune time. This flexibility gives rise to an option value which, although this is a real market (the land market), is akin to option values on the financial markets.

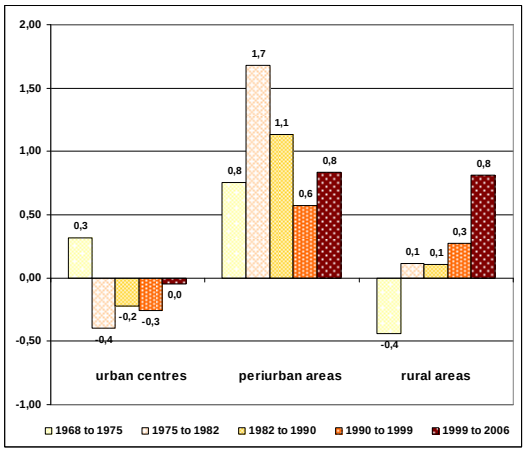


Figure 1. Migration balance between censuses (1968–2006)

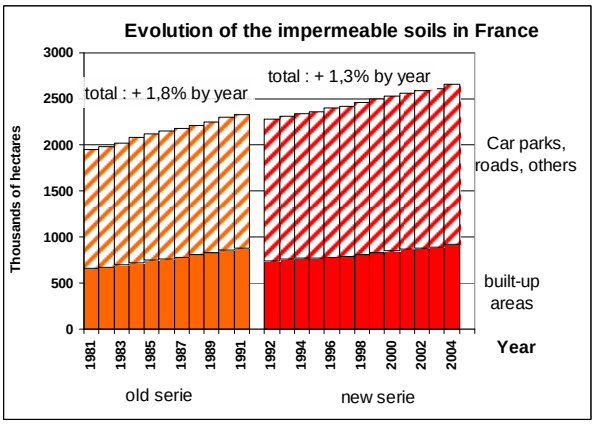


Figure 2. Changes in impermeable soils in France (1981–2004)

Here we study the operation of the market for developable land in one French department, the Nord, and compare it with two other study regions (the Côte d'Or department and a broad area around Toulouse). The econometric model is derived from urban economics. It allows for effects of distance, population, inhabitants' income, etc. and for two types of option value.

The classical option value results from real-estate price volatility, which creates uncertainty about the selling price of the property that will be put on sale when development is completed. Price variability over the quarters before the transaction takes account of this volatility. Figure 3 shows that variability is high: unit prices frequently vary by ± 10% from one month to the next (the largest fluctuations may be due to exceptional transactions). There is also a second uncertainty about the future price related to the long-term price. A household that buys housing in a periurban commune does not know what it will be worth when it comes to sell it or when it is inherited, generally 10, 15 or 20 years later. This future price depends on what demand will be at that time horizon. It may therefore be rational to wait for further information about the change in demand before purchasing a plot in any particular place. The variability in population change by commune between censuses within a 10 or 15 km radius is therefore introduced into the model to allow for this long-term uncertainty and for the option value it may engender. Figure 4 shows that, in the Nord, some zones have positive and others negative population growth (1982–2006). It can also be seen that long-term patterns can sometimes be fairly similar for neighbouring communes, while in other instances local patterns may be more contrasted. It is difficult, then, to anticipate any change in population.

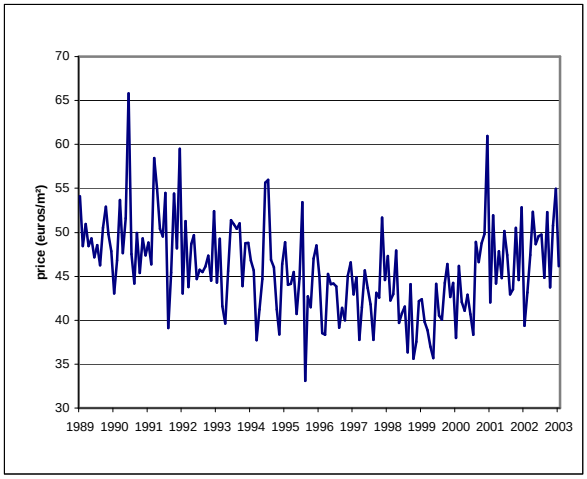


Figure 3. Price per m² of developable land by transaction date (Nord)

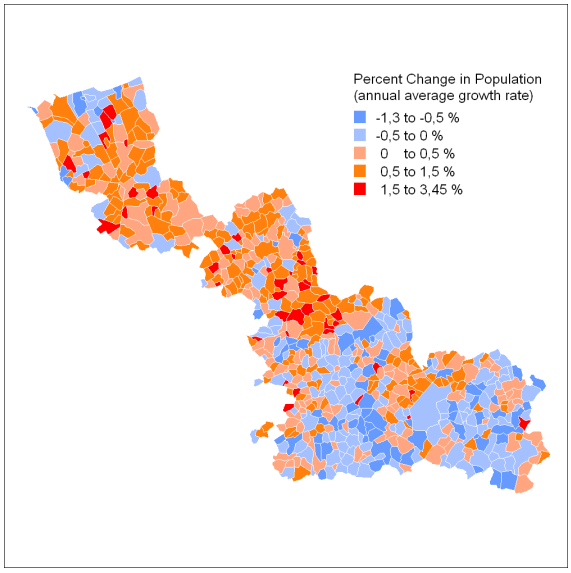


Figure 4. Population change by commune in the Nord (1982–2006)

The essential data base used in this study is made up of individual transactions for developable land for residential purposes (19 495 observations) or secondary or tertiary activities (1667 observations) between 1989 and 2002 in the Nord. Similar estimations are made for the other two study areas based on fewer individual data and for a shorter period, to test whether results are comparable.

After summarizing the literature on real-estate market option values (Section 2), we develop the econometric model (Section 3) and the estimation methods (Section 4). The results are set out in Section 5, and Section 6 concludes.

2. The literature

2.1. Theoretical literature on developable land prices

Suppose an 'open city' as understood in urban economics, that is, a city where costless migrations from the rest of the world make it possible to attain urban equilibrium when the utility of the city's inhabitants is equal to that of the rest of the world. Space is made up of a line $\Lambda =]-\infty,+\infty[$ the origin of which is occupied by the point-shaped Central Business District (CBD), where non-agricultural jobs are concentrated. Two types of agent are in competition on the land market: households, which are all identical; and farmers, who are all identical.

The simplest case of urban economics (Alonso, 1964; Fujita, 1989; Muth, 1969) is that of a static model where space is homogeneous. The price of residential land varies with ease of access to the CBD. The price of farmland, R_A, is constant if it is all equally fertile (no Ricardian rent) and if the cost of transporting agricultural commodities is zero (no von Thünen-type rent). On the boundary between the city and agriculture, the residential land rent is equal to the agricultural land rent.

Suppose now that agents anticipate population growth of the city in a deterministic world. The models of Capozza and Hesley (1989), Brueckner (1990) and more recently of Hardie *et al*. (2001), Plantinga and Miller (2001) and Cavailhès and Wavresky (2003) correspond to a theoretical framework of this kind. Arnott and Lewis (1979) had already introduced such a model in 1979. The price of residential land P_H is equal to the capitalization of the current

residential land rent R_H and of the anticipated future rent, which is in turn a function of the population growth rate g. If i is the discount rate, we get, as Capoza and Li show (1994):

$$P_H = \frac{R_H}{i} + \frac{g}{i^2}.$$

In a deterministic world, farmland is converted into developable land at a date t^* such that $P_H > \frac{R_A}{i}$.

This is not so in a stochastic world, since the promoter runs the risk of the residential rent, which obeys a random process, falling below the agricultural rent once the land has been developed. For reasons of (i) uncertainty, (ii) irreversibility of development and (iii) the arrival of information over the course of time, it is rational to put off conversion until some future date, and the greater the random price fluctuations the more distant that date will be (Dixit, 1989). The option value associated with developable but not yet developed land and which is conditional upon the arrival of information rises and falls with price variability. Capozza and Hesley (1990), Capozza and Li (1994), Cunningham (2006), Fisher and Hanemann (1990), Plantinga *et al*. (2002) and Tenege *et al*. (1999) study the workings of the land market under such circumstances.

Suppose that the land owners are risk neutral. If D is the cost of servicing the land, the land owner's expected profit $\Pi(x)$ for land located at *x* and converted at date t^* is

$$\Pi(x) = E\left[\int_0^{t^*} R_A e^{-is} ds + \int_{t^*}^{\infty} R_H(x) e^{-is} ds - D e^{-it^*}\right]. \qquad \textbf{(1)}$$

Suppose that the residential land rents follows a Brownian process with trend g and variance σ^2: $R_H(x, t+s) = R_H(x,t) + gs + \sigma B(s)$, where B is a Brownian motion of trend 0 and variance 1.

By partial integration of the second part of (1), recalling that $E[\sigma(t+s)] = 0$

$$E\left\{\int_{t^*}^{\infty} \left[R_H(x) + g(s-t^*) + \sigma(s-t^*)\right] e^{-is} ds\right\}$$
$$= E\left[\left(\frac{R_H(x)}{i} + \frac{g}{i^2}\right) e^{-it^*}\right].$$

The owner's profit can be written:

$$\Pi(t^*, x) = \frac{R_A}{i} E\left(1 - e^{-it^*}\right) + E\left[\left(\frac{R_H(x)}{i} + \frac{g}{i^2} - D\right) e^{-it^*}\right]. \qquad \textbf{(2)}$$

The owner chooses t^* to maximize (2). This is an optimal stopping problem where conversion occurs when a reserve value $R_H^*(x)$ is reached. Plantinga *et al*. (2002), drawing on Karlin and Taylor (1975), show that:

$$e^{-it^*} = e^{-\alpha\left(R_H^* - R_H\right)},$$

where:

$$\alpha = \frac{\left(g^2 + 2\sigma^2 i\right)^{1/2} - g}{\sigma^2}.$$

The optimal profit $\Pi^*(x)$ is :

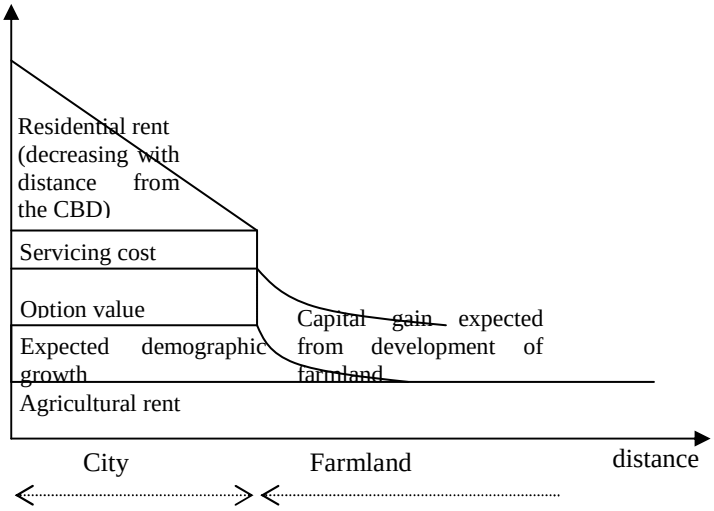
$$\Pi^*(x) = \frac{R_A}{i}\left\{1 - e^{-\alpha\left[R_H^*(x) - R_H(x)\right]}\right\} + \left[\frac{R_H^*(x)}{i} + \frac{g}{i^2} - D\right] e^{-\alpha\left[R_H^*(x) - R_H(x)\right]}. \quad \textbf{(3)}$$

The reserve value $R_H^*(x)$ is obtained by differentiating (3) with respect to $R_H^*(x)$:

$$R_H^*(x) = R_A + iD + \frac{i - \alpha g}{\alpha i}.$$

The land price is illustrated in Figure 5, which is inspired by Capozza and Hesley (1990). The land price breaks down into five parts: agricultural opportunity rent, expected population growth, option value, servicing cost and the term resulting from the trade-off between the cost of transport to the CBD and the land cost. Population growth is anticipated too by the owners of farmland which also has an option value, explaining why the agricultural land rent decreases with distance from the city up to a certain point beyond which there is no further urban influence (‘remote rural’).

Figure 5. Land prices in a city with stochastic growth



2.2. Econometric literature on option values

We concentrate here on two papers that use this theoretical framework to estimate the option value of developable farmland.

Plantinga *et al.* (2002) estimate an econometric equation that is a reduced form involving population growth and its square (inert expectation reproducing the past), its variance and its square, and terms for interaction between these variables and the agricultural and residential rents. They use aggregate data for all US counties. The results show that population density raises the price of farmland, and its variance, which is interpreted as capitalization of the option value. Anticipation of conversion represents about 10% of the price of farmland and up to half in the most urbanized counties.

Cunningham (2006) uses individual data in a county of the Seattle area (463 000 transactions and 531 000 lots). He investigates the two effects related to option values:

reduction in the supply of land and increase in price. The two models are quite close. We concentrate here on the second aspect, price.

Cunningham (2006) begins by estimating the uncertainty about price from a classical hedonic price model enabling him to obtain a quarterly predicted price for the various zones (essentially four school zones). He then estimates the regression of this predicted price on the predicted price of the same zone four quarters earlier: $P_{it} = \alpha_{0i} + \alpha_{1i} P_{i,t-4} + \varepsilon_{it}$ and so calculates a moving variance over four quarters. This variance is then introduced as an explanatory variable for developable land price in a second hedonic equation. The other regressors are distance to the centre of employment, view quality, dangers of erosion, flooding, seismic risk, slope of the land, lot shape, etc.

The results show that uncertainty has a big effect on land retention: the supply of developable land declines by about 11% for an additional standard deviation of uncertainty about the real-estate price. Uncertainty also has a significant but more modest effect on price (+ 1.6% for an additional standard deviation). These effects are also estimated for belts at varying distances around Seattle: they are substantial mostly in a belt between 12 and 20 miles from the city centre.

3. The model

The model presented here enhances those we have just examined by distinguishing two option values. When a household buys a plot to build a house on, it has two time horizons in mind. The first is between one and two years, which is the period between the moment the purchase is made and the moment it can move in. At this time horizon, it could buy an existing house, whether a new build or not, at a market price it does not know exactly at the time of purchasing the land. So it must weight the cost of its project and this future price. A promoter developing a housing estate is in the same position: at the time she takes the decision to buy the land, she does not know the future price the houses will sell at. Secondly, the household generally has an idea of the price at which it will be able to resell the house when it leaves, after a generally long period (property turn-over is slow in France). It may also be thinking of the asset value of the house if it is contemplating passing it on as an inheritance. We deal here with these two aspects of uncertainty about future prices, emphasizing the second one, because as far as we know it has never been considered in the literature.

3.1. Option values associated with long-term risk

Suppose that the influx of population into a commune is a stochastic process. It is judicious, then, to await new information about migratory flows before deciding about purchasing a plot of land. An option value then arises, which must be reasoned about on a much longer time scale than in the classical case of short-term market risk.

In addition, the arrival of migrants presupposes non-recoverable municipal investments that are financed by the commune through long-term loans. It is rational for the mayor to wait for information about migratory flows in order to decide on building new housing that would entail such investments,[2] by using a land zoning scheme (plan local d'urbanisme, PLU[3]). The

[2] This is a hypotheses made by Lecat (2006).

[3] A PLU entitles the municipality to chose the annual volume of building permits, and so the rate of arrival of migrants, or to postopone such arrivals.

outcome of this is a restricted supply of developable land and an option value that is capitalized in the price of plots.

Whether it is a matter of the household reselling the housing or the scaling of municipal facilities, we suppose that the distance to the CBD plays the same role as time in classical models of option value. The change in population p_j (upper case P is for plot price and lower case p for population of the commune) of commune j for an increment in distance dx (equivalent to the time increment dt) follows a trend, upon which random oscillations are superimposed.

We assume that the decision makers (the household buying a plot or the mayor having amenities built) examine the change in population within a given neighbourhood and that the variance of these changes increases with distance. Anticipation depends on many factors which are increasingly uncertain as distance to the CBD increases: transport costs, technical improvements to cars, which may be quite radical (electrical, hydrogen engines), allowance for social costs (climate change, pollution), transport network development, working from home, etc. These assumptions lead us to chose to write a Brownian geometrical motion: $dp_j = \alpha p_j dx + \sigma p_j \varepsilon_t \sqrt{dx}$, where α is the trend and $\sigma\varepsilon_t$ the uncertainty (ε_t is a random variable with zero mean and unit variance). Uncertainty increases with distance x in linear log form (dp_j / p_j follows Brownian motion).

3.2. The econometric model

To model short-term option values (temporary price volatility) we look at 'pure' price variability over time, that is, by controlling a set of variables *X* that affect this price and vary over the course of time (plot size, remoteness, etc.). The starting equation is $d\tilde{P} = \alpha_1 dt + \sigma\varepsilon_t \sqrt{dt}$, where $\tilde{P}$ is the change in the price of land over the period *dt* under the 'pure' influence of time, that is, having expurgated factors of variation included in *X* and where ε_t is a random variable of zero mean and of unit variance; α is the trend and σ^2 the price variance. $\tilde{P}$ is estimated by a random-effect model

$$P_{ijt} = X_{ijt} b + b_t T + \upsilon_t + \varepsilon_{ijt}, \qquad \textbf{(4)}$$

where the price P_{ijt} of transaction *i* in commune *j* and in the period *t* is explained by a set of variables *X*, by a continuous time variable *T* capturing the trend, by a random variable υ_t that is dependent on the period *t* and the model's group level (we use a quarter given the number of data) and by an individual error ε_{ijt}. The variance of υ_t, calculated by (5), is then introduced into the explanatory model of land price

$$\hat{\tilde{\sigma}}_t = \frac{1}{12} \sum_{l=t-12}^{t-1} \left(\hat{\upsilon}_l - \bar{\hat{\upsilon}}\right)^2, \qquad \textbf{(5)}$$

where the 'hats' designate the υ_t values estimated by (4) and the 'bar' represents the mean of these values estimated for the 12 months before *t*. $\hat{\tilde{\sigma}}_t^2$ has both a 'tilde' and a 'hat' because it is a variance calculated (hence the tilde) from estimated values (hence the hat). The equation to be estimated becomes

$$P_{ijt} = X_{ijt} b + b_{1t} T + b_{\sigma t} \hat{\tilde{\sigma}}_t + \varepsilon_j + \varepsilon_{ijt}. \qquad \textbf{(6)}$$

The long-term option values are introduced in the same way

$$\ln P_{ijt} = X_{ijt}b + b_T T + b_{\sigma t}\hat{\tilde{\sigma}}_t + b_p \Delta p + b_{\varepsilon p}\hat{\tilde{\varepsilon}}_p + \varepsilon_j + \varepsilon_{ijt}\,, \qquad \textbf{(7)}$$

with:

$$\hat{\tilde{\varepsilon}}_p = \frac{1}{w-1}\sum_{l=1}^{w}\left(\tilde{\varepsilon}_l - \bar{\tilde{\varepsilon}}\right),$$

where $\hat{\tilde{\varepsilon}}_p$ is the standard deviation of variation of population change over time during the period in the communes around j within a neighbourhood w and Δp is the change in population over this period. This standard deviation is calculated directly from population censuses.[4] The standard deviation of population on which households base their decision to purchase must be observed over a long enough period. We generally use the period between the 1982 and 1999 censuses.

4. Data and estimation methods

The data are from two sources:

- The Regional Housing and Development Office (Office régional de l'habitat et de l'aménagement, ORHA) for the Nord–Pas-de-Calais region. This source includes all transfers of ownership of developable land between 1989 and 2002. After working through the file and excluding the extreme centiles, we have 40 854 observations, of which we select those for 'secondary or tertiary activities or infrastructures' (3322 observations) and those for 'individual developable plots' (31 551 observations).
- Perval, a corporate source whose records are supplied by solicitors (with variations over time and space), is used for the other two study areas. After auditing the file and leaving out the extreme centiles, we have for the years 2000, 2002, 2004 and 2006 some 2398 observations for developable land in the Côte d'Or and 10 293 observations in the Toulouse area.

The transactions were georeferenced from plot identifiers in the land registry (which sometimes had to be re-coded to be of use) by matching them up with the geographical coordinates of the centroids of the land registry plots, extracted by geomatic or manual processing from the land registry files. As not all the observations could be georeferenced, the sample used for the estimations was composed of 19 495 transfers of ownership of developable land and 1667 transfers of ownership of land for secondary and tertiary activities (ORHA, Nord), of 2022 developable plots in Côte d'Or and 5276 in the Toulouse area.

The transaction price, which is the dependent variable, is introduced in log form (a Box-Cox transformation at an earlier stage shows that the transformation parameter λ is close to 0). The plot area, which is the variable that contributes most to explaining the price, is introduced in polytomized form (twentiles or deciles). Various location variables were added to the data base: inclusion in urban zoning schemes (basins and urban areas[5]), distance by

[4] The control for migration rate and its variability by the inclusion of zoning schemes entails a selection bias: the standard variation of population in the neighbourhood w should be calculated from the variability of population in the communes without a zoning scheme (observed) and from what it would have been in communes with zoning schemes had they not been introduced (counterfactual). This selection bias will be allowed for at a later stage of research.

[5] 'Basins' are the catchment areas of market towns or cities where ordinary goods and services are purchased and that have basic public facilities. 'Urban areas' are zones within which people commute to centres of employment

road between communes (in kilometres using the INRA-CESAER Odomatrix application), distance as the crow flies between the plot and the centre of the village or town of the commune it belongs to. The distance variables are introduced in linear form. We tested the effect of distance to the commune at the basin centre and the commune at the centre of the nearest urban area and selected those that were significant at the 5% level. Population variables pertain to the population, changes in population and the income of the inhabitants of the commune and sometimes of neighbouring communes. Finally, other control variables were introduced, such as the presence of land zoning schemes (PLU).

The breakdown of the error term in (7) can result in spatial autocorrelation of the corresponding random variables.[6] In this event, the estimators would be inconsistent. We have examined the spatial correlations among the random variables for the communes and among the individual error terms. The linkages between neighbouring communes are subjected to a Moran's I null test (for a neighbourhood defined by a 5 km radius with weighting by the inverse of distance from town hall to town hall). When this index is significantly non-zero, spatial autocorrelation is corrected for by introducing a term $W\hat{\varepsilon}_j$, where W designates the spatial neighbourhood matrix (same definition) and $\hat{\varepsilon}_j$ the random variable estimated for commune j in a first stage of estimating (7). We then verify, by the Moran's I null test of the new values of the commune random variable, $\varepsilon_j^{'}$, that autocorrelations among neighbouring communes are no longer significant.

The approach is identical for linkages among individual error terms. Georeferencing of transactions means neighbours can be identified (we use a 200 m radius) and a Moran's I calculated (weighted by the inverse of distance) to test whether it is null. If a value is significantly different from zero, a second correction is made to the equation (7).[7]

5. Results

5.1. Developable land for housing in the Nord

Table 1 shows the results for plots for individual houses in the Nord. The fixed factor of the equation is composed of surface area twentiles (not listed in Table 1), the year of transaction, the population, the average taxable income of households in the commune and in neighbouring communes, the change in population of the commune at the basin centre (1982–1999), whether or not there is a zoning scheme in the commune, the distance to the basin centre and the distance to the nearest motorway junction. The distance to the town hall is also worked into the equation, by interaction with variables indicating the size of the commune. We shall comment briefly on the values of parameters of these variables to emphasize more the effects of spatial variability of the population and variability of prices over time that are used as regressors in conjunction with the phases of downturn (1989–1997) and upturn (1998–2003) in the real estate cycle (cf. Figure 3), to allow for the fact that uncertainty about the future does not operate in the same way throughout the cycle (Madj and Pindyck, 1987).

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with more than 5000 jobs. These zones are determined by France's statistics office (Institut national de la statistique et études économiques, INSEE).

[6] It may be too that the random variable characterizing the commune is correlated with variables of the fixed factor, giving rise to endogeneity. At this stage in the research we have no instruments for correcting for this possible source of bias.

[7] This could not be done for individual developable plots in the Nord as the computer had insufficient memory to process the large number of data. However, it was done for plots for secondary or tertiary activities in the Nord and for all plots in the Côte d'Or and Toulouse study areas.

	Before correction of spatial autocorrelations (commune level)		After correction of spatial autocorrelations (commune level)	
	parameter	Student t	parameter	Student t
Intercept	-41.7279	-7.67	-42.508	-7.79
population of the commune and adjoining communes (1999, logarithm)	0.1061	7.5	0.09304	6.63
Evolution of the population of the basin centre (1982-1999)	2.2205	4.99	2.2816	4.96
distance from the basin centre (kilometres)	-0.00964	-3.84	-0.01064	-4.27
distance to the highway on ramp	-0.00738	-2.52	-0.00736	-2.54
Mean income or the inhabitants on the commune and adjoining communes (1999, thousands of euros)	0.04037	7.93	0.03747	7.47
Land zoning scheme in the commune	0.1132	4.44	0.1028	4.06
absence of zoning scheme in the commune	Reference		Reference	
distance from the commune centre according to the population:				
less than 1000 inhabitants	-0.00744	-0.85	-0.00492	-0.5
1000 to 2000 inhabitants	-0.1129	-8.43	-0.1162	-8.6
2000 to 5000 inhabitants	-0.05334	-6.69	-0.05231	-6.58
5000 to 10000 inhabitants	-0.07369	-5.92	-0.07211	-5.81
10000 to 50000 inhabitants	-0.06522	-7.7	-0.06522	-7.75
more than 50000 inhabitants	-0.06323	-4.78	-0.062	-4.71
year of transaction	0.02521	9.26	0.02565	9.4
standard deviation of the developable land price during the 6 previous quarters:				
period 1989-1997	8.6585	8.39	8.8271	8.53
period 1998-2002	8.7796	30.05	8.7559	29.88
standard deviation of the population evolution (1982-1990) in the commune and the 10 nearest communes:				
period 1982-1997	-0.05856	-7.56	-0.05841	-7.53
period 1998-2002	0.07455	6.27	0.07847	6.59
rho (spatial autocorrelation, commune level)			0.2994	2.8

Non-reported: twentiles of surface

Table 1. Results: developable plots for detached housing (Nord)

When the population of the commune and the adjoining communes rises by 1000 inhabitants, the price of developable land increases by almost 10%. The income of the household of the commune and the adjoining communes has a significant effect: price rises by 3.8% when income rises by €1000, which is consistent with the classical mechanism of capitalization of neighbourhood externalities. The population change in the basin centre between 1982 and 1999 also influences price, as does distance from that centre which also acts as expected: price falls by 1% for each kilometre further away the plot is. The distance of the plot from the town hall also has an effect, except for communes with fewer than 1000 inhabitants: the fall in price is between 7 and 13% depending on commune size.

Short-term market volatility and long-term population volatility give rise to significant option values. We tested standard deviations for lags of 4, 6 and 10 quarters and different permutations for standard deviations of population (10 or 15 km, 1982–1999 censuses), which lead to parameters that are all positive and significant (we selected the most significant permutation in each instance). This yields highly robust results.

A variation of one standard deviation of the standard deviation of the plot price within the six quarters before a transaction entails a price increase of 7.4% during the downturn of the real-estate cycle and of 15.3% during the upturn period. The value of these standard deviations is of 0.7 (downturn period) and of 1.3 (upturn period) and the standard variations

of these variables are 0.8 and 1.7, respectively. Variability is therefore high compared with the value of the standard deviations themselves. The option value due to short-term volatility of the market is 6% and 26% of the plot price during each of the periods respectively (= 7.4 * 0.8 and 15.3* 1.7).

The spatial variability of population change also has significant effects. During the period of downturn of real-estate prices (1989–1997), the parameter obtained is negative. The interpretation of real-estate option values in the downturn period seems difficult to us from the standpoint of theory. We therefore set little store by this result. During the upturn period (1998–2002), the parameter is significantly positive. An increase of one standard deviation (0.36) of the standard deviation of population growth (mean value 0.22) works out as a 6% rise in plot price. Over this period, the long-term option value is therefore 1.3% of the plot price (= 6* 0.22).

5.2. Developable land for secondary or tertiary industries in the Nord

Table 2 shows the results for developable land for secondary or tertiary activities in the Nord.

The fixed factor is composed of surface area twentiles (not shown in the table), commune population and mean taxable income of its inhabitants, the presence or absence of a zoning scheme in the commune, the distance to the basin centre and to the nearest motorway junction. The distance to the commune's town hall is also included in the equation.

The change in the commune population is reflected by an increase in land price, with elasticity of 0.23. When the mean income of households in the commune rises by €1000, the plot price rises by 2.5%. The presence of a zoning scheme entails a price rise of 27%. Accessibility is reflected by a 1.7% fall in price per kilometre for distance from the basin centre and a 1.4% fall per kilometre for distance from the nearest motorway junction. The distance between the plot and the town hall of the commune affects the price of these plots, except for communes of less than 1000 inhabitants. The fall in price depends on the commune's population, ranging from – 6.2 and – 11% per kilometre.

	Before correction of spatial autocorrelations (commune level)		After correction of spatial autocorrelations (commune level)	
	parameter	Student t	parameter	Student t
Intercept	7.3095	17.56	7.5111	20.13
population of the commune (1999, logarithm)	0.2538	7,0	0.2321	7.1
distance from the basin centre (kilometres)	-0.01483	-2.37	-0.01737	-3.09
distance to the highway on ramp	-0.01235	-1.57	-0.01429	-1.97
Mean income or the inhabitants on the commune (1999, thousands of euros)	0.02789	3.51	0.02496	3.66
Land zoning scheme in the commune	0.2324	2.17	0.2373	2.43
absence of zoning scheme in the commune	Reference		Reference	
distance from the commune centre according to the population:				
less than 1000 inhabitants	-0.01314	-0.14	-0.00125	-0.01
1000 to 2000 inhabitants	-0.1154	-1.36	-0.126	-1.63
2000 to 5000 inhabitants	-0.2259	-4.83	-0.2225	-5.02
5000 to 10000 inhabitants	-0.2369	-3.62	-0.2334	-3.83
10000 to 50000 inhabitants	-0.2888	-6.72	-0.26	-6.44
more than 50000 inhabitants	-0.2294	-4.79	-0.1924	-4.32
standard deviation of the developable land price during the 6 previous quarters:	-1.1925	-1.4	-0.8434	-1.02
standard deviation of the population evolution (1982-1990) in the commune and the 10 nearest communes:				
period 1982-1997	-0.07709	-1.55	-0.07314	-1.65
period 1998-2002	0.1536	2.9	0.1528	3.23
rho (spatial autocorrelation, commune level)			0,4782	10,8

Non-reported: twentiles of surface

Table 2. Results: developable land for secondary or tertiary activities (Nord)

Plots for secondary and tertiary activities or for infrastructures do not give rise to option values related to short-term volatility. This may be because the seller cannot choose the date the property is put on the market. For land for economic activities or public-sector development, the purchaser can impose the transfer date, sometimes by threatening expropriation if public utility can be invoked. For there to be an option value, the owner of the plot must be free to choose the moment to make a sale. The small number of observations for calculating quarterly standard deviations may also have an effect: there are 63 on average and sometimes half as many for some quarters.

The option value resulting from volatility in the change of population is tested by introducing the standard deviation of population change in the 10 adjoining communes between 1982 and 1990, which is the most significant variable. It is included in the regression by distinguishing two sub-periods, 1989–1997 and 1998–2002. During the first period, this variable has no effect (it is slightly negative) whereas in the upturn period it results in a significant rise in land values: when the standard deviation of population growth increases by a standard deviation (+%), the plot price of land for secondary and tertiary activities or infrastructure rises by 4.4%. This is consistent with our hypothesis, but seems to contradict the lack of short-term variability of price: if the seller has no control over the moment of selling, there should be no option value in either case, and if he can choose the date there should be an option value in both cases.

5.3. Comparisons with the Côte d'Or and the Toulouse area

The results for the Toulouse area and the Côte d'Or are shown in Table 3.

The slope of land values with distance from centres is different in the three study regions. In the Toulouse area, it is – 1.2%/km from the nearest basin centre and – 1.6%/km from Toulouse. In the Côte d'Or, the values are respectively – 2.9%/km and – 1.2%/km from Dijon. In the Nord, the slope is only – 1.0%/km from the basin centre. The hierarchy of results is fairly consistent. The Nord is a department with many centres, where the population is dense and the urban fabric is close-knit (43 basins). Accordingly developable land is invariably close to an urban and/or basin centre. The Côte d'Or is a department where Dijon is the only sizeable city and where the urban fabric is very loose (18 basins). This means that the effect of distance from Dijon is felt up to the boundaries of the department and is particularly strong in the Dijon urban area. It is a medium-sized city (150,000 inhabitants), where the road and public transport networks are not as developed as in the much larger city of Toulouse. In the Toulouse area, the slope of land values is smaller, which probably reflects better service by public transport and better cover by fast access roads. This is logical enough in a city of its size (445,000 inhabitants in Toulouse itself, 1.1 million in its urban area).

In all three areas, there is also an accessibility gradient on commune scale: prices fall with distance from the town hall, which is generally located in the village or town centre, where public-sector activities and the supply of private goods and services are concentrated. This effect is slight (Côte d'Or) or non-existent (Nord and Toulouse) in communes of fewer than 1000 inhabitants, probably because such public or private goods are not abundant in these small communes. The effect is felt in more populous communes. In the Toulouse area, prices fall by 4 to 8% per kilometre with distance from the town hall (depending on commune size). This slope is lower than that in the Nord (– 5 to – 12%/km, depending on commune size) and above all in the Côte d'Or (– 36%/km for communes of more than 1000 inhabitants). The slope is therefore steeper where settlement is clustered (Côte d'Or), which reflects a concentration of public services (schools, etc.) and shops in the centre of these market towns and perhaps a lower value of a peripheral location in these regions of plains and plateaux of north-eastern France, where the age-old tradition is one of clustered settlement. The fall in land values with distance from the commune centre is not as sharp in the Toulouse area, where the distance to travel to school or to the shops seems to be offset by other advantages (large residential plots for building swimming pools, barbecues, etc.) and where dispersed settlement is rooted in the ancient history of the mosaic countryside of southern France.

	Toulouse region						Côte d'Or department			
	Before correction of spatial autocorrelations (commune level)		After correction of spatial autocorrelations (commune level)		After correction of spatial autocorrelations (commune and		Before correction of spatial autocorrelations (commune level)		After correction of spatial autocorrelations (individual level)	
	parameter	Student t	parameter	Student t	parameter	Student t	parameter	Student t	parameter	Student t
distance from the urban area centre (kilometres)	-0.01623	-14.04	-0.0153	-12.63	-0.01543	-13.19	-0.01302	-3.33	-0.01171	-3.14
distance to the highway on ramp	-0.01191	-5.98	-0.01229	-5.92	-0.01197	-6.12				
distance to the nearest basin centre	-0.00195	-1.38	-0.00202	-1.36	-0.00239	-1.7	-0.03021	-4.32	-0.029	-4.32
population of the basin centre (1999, thousand)							0.004042	2.42	0.004016	2.55
Evolution of the population of the basin centre (1982-1999)	0.5088	2.91	0.5056	2.9	0.4906	2.94	1.637	2.05	1.6387	2.15
population of the commune or/and adjoining communes (1999)	0.00235	3.86	0.002262	3.89	0.002529	4.76	0.01127	3.05	0.0121	3.4
Mean income or the inhabitants on the commune or/and adjoining communes (1999, thousands of euros)	0.02183	5.13	0.0236	5.42	0.02418	6.06	0.01882	2.14	0.01863	2.21
Land zoning scheme in the commune	0.08156	3.36	0.05965	2.37	0.05977	2.59	-0.07038	-0.62	-0.1215	-1.12
absence of zoning scheme in the commune	Reference		Reference		Reference		Réf.		Réf.	
distance from the commune centre according to the population:										
less than 1000 inhabitants	-0.01198	-1.37	-0.00924	-0.92	-0.00554	-0.6	-0.1984	-3.41	-0.1752	-3.14
1000 to 2000 inhabitants	-0.03373	-3.29	-0.03524	-3.28	-0.04346	-4.37				
2000 to 5000 inhabitants	-0.03477	-4.35	-0.03248	-3.81	-0.02734	-3.46	-0.3444	-7.43	-0.3616	-8.18
5000 to 10000 inhabitants	-0.07394	-6.38	-0.07449	-6.51	-0.08029	-7.58				
10000 to 50000 inhabitants	-0.03321	-3.36	-0.05228	-4.77	-0.05518	-5.44				
more than 50000 inhabitants	-0.03519	-3.55	0.0107	0.53	0.01739	0.93				
presence of a structure on the parcel							0.2403	6.15	0.2073	5.54
presence of a small structure on the parcel							0.03965	1.11	0.03714	1.09
zones of the land scheme										
A zone (agriculture)							-0.4084	-2.06	-0.3947	-2.08
N zone (nature)							-0.6708	-4.39	-0.5529	-3.78
U zone (developable)							0.2565	8.11	0.3046	10.03
other zones							0.2556	2.12	0.2164	1.88
standard deviation of the population evolution (1982-1999) in the commune and the 15 nearest communes:	0.1172	5.57	0.1227	5.59	0.1107	5.47				
rho (spatial autocorrelation, commune level)			0.3061	2.5	0.3527	3.14				
rho (spatial autocorrelation, individual level)					0.5589	32.97			0.4868	12.05

Table 3. Results: developable land, Toulouse area and Côte d'Or.

The Côte d'Or allows a more precise analysis of urban zoning effects than the two other study regions. The local zoning schemes (plans locaux d'urbanisme, PLU) have been digitized, which, with the geolocation of plots, means we can determine which PLU zone they are located in. The plots belonging to communes without zoning schemes are the reference. Where there is a zoning scheme, plots within a farmland or undeveloped zone are respectively 32% and 42% less expensive than the reference, whereas in a developable zone they are 35% more expensive. The existence of a zoning scheme therefore entails sharp jumps in price depending on the zone.

It has not been possible to introduce the short-term price volatility option value into equations for want of sufficiently long time series in the Toulouse area and the Côte d'Or. Besides, we have only 2022 exploitable observations for the Côte d'Or. In the Toulouse area, long-term option values engendered by the spatial volatility of population can be estimated from lower numbers than in the Nord, but the numbers are sufficient for the results to be robust.

In the Toulouse area, the different standard deviation permutations of population are all significant. The permutation selected (change 1982–1999 in the 15 nearest communes) displays an important effect. A one standard deviation increase (0.48) of the standard deviation of the population change (therefore the mean value is 1.2) is reflected by a 5.6% increase in plot price. The option value therefore represents 2.7% of plot price (5.6*0.48).

In Côte d'Or, the variability of population change in the 10 or 15 nearest communes for the periods 1982–1990, 1982–1999 and 1990–1999, has no significant effect on the price of developable land: the Student's t-test is close to 1.5 at best.

6. Conclusions

We have concentrated in this paper on the land capitalization of option values related to uncertainty, which modifies the behaviour of sellers when the transaction involves an irreversible factor, such as development. Such uncertainty may bear on the change in price over time or on the change in population in space. The analysis was conducted for the Nord and comparisons made with the Toulouse area (extending beyond the urban area of Toulouse) and the Côte d'Or. The question of the role of distance and of accessibility to urban centres in the formation of land values has also been examined on different scales: from the regional metropolis to the main village of the commune.

The results for option values are contrasted. The inclusion in the plot price of option values arising from market risk, that is, from price volatility over time, has been estimated for the Nord, where it is significant. This confirms the conclusions of work for other countries. The effects of spatial variability of population change on land values have been analysed in the three study areas. The results show that, in some cases, the effects are not significant. This may be, obviously, because of the inaccuracy of the theoretical hypothesis, but also because of too few observations (Côte d'Or) or because the hypotheses of the theory do not hold up for some market segments. This is the case in the Nord for plots for 'economic activities or infrastructures': the purchaser can impose the sale at the right time for her by invoking the public utility of the operation and therefore brandish the threat of expropriation.

For developable land for detached housing in the Nord and the Toulouse area, the results show that the price of goods is significantly higher when the change in population in the adjoining communes is volatile, and so difficult to predict. The option value associated with such volatility is low: from 1.3 to 2.7% of the plot price.

It can be concluded that more work of the kind is required to gain a better understanding of why the results are not significant in some cases but are in others and why their level of significance in the Nord and the Toulouse area cannot be a matter of pure chance: there does seem to be long-term risk, related to the difficulty of predicting the change in population and therefore in predicting demand at a time horizon of ten years or more.

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