Expansionary zoning and the strategic behavior of local governments. Evidence from the metropolitan area of Madrid

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October 31, 2016

Abstract

This paper analyses to what extent local land supply is the result of strategic interaction among local governments. In a setting of limited tax instruments to raise revenues and interjurisdictional competition for mobile residents, municipal authorities are provided with the economic incentives to convert land from rural to urban uses, hence promoting urban growth. Using data on the municipalities within the metropolitan area of Madrid from 2000 to 2007, we report evidence in support of this hypothesis. Estimated reaction functions suggest that local incumbents do not make policy decisions in isolation: a local governments decision on land-use conversion is positively influenced by the decisions of other nearby local governments.

Keywords: local land supply, land-use conversion, residential development, local governments, spatial econometrics.

JEL codes: C21, H7, R14 .

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1 Introduction

A long line of research in economics analyzes the factors that shape local land-use regulation. Land regulation can influence the amount, location and shape of urban development, with a non-negligible impact on land rents and housing prices, environmental quality, transportation costs, and even labor markets (Lenon *et al.*, 1996). It is not surprising, then, that many economists have focused their attention on developing theories aimed at determining the drivers of land regulation. As recently surveyed in Gyourko and Molloy (2014), the reasons why regulation arises are mainly threefold: *(i)* the role of homeowners, owners of vacant land and land developers in the local political process and their incentives to either promote or restrict development, *(ii)* a limited supply of vacant land, resulting either from topographical constraints or previous development and *(iii)* zoning policies (including minimum lot sizes, maximum density restrictions, parking requirements and aesthetic rules) that reflect the intention of local governments to alter land use and control the amount and quality of residential development in their jurisdiction. Zoning was initially designed to separate land uses and prevent unhealthy overcrowding of cities; but also intentionally used as an exclusionary tool (by raising the price of housing, hence making certain neighborhoods inaccessible to low- or middle-income families).

Thus far, however, research has focused on land-use regulation as a tool to limit urban expansion. But what happens when land use decisions cause inefficient urban growth by devoting more land to urban development than the freer market would? Under which circumstances would local incumbents be willing to do so? The present paper seeks to provide some insights in this regard. In a *Tiebout* setting where middle and upper income residents shop among rival nearby locations, local governments will compete to attract those mobile residents to their jurisdictions, as it translates to broader tax bases and higher tax revenues.[1] This competition becomes particularly relevant in an environment where local authorities have limited fiscal capacity and a limited set of tax instruments to raise revenues. This being the case, land use conversion for residential uses becomes an important source of finance for local governments, as land-based financing has the biggest payoff where there is rapid urban growth.

[1]That is, more revenues linked to land-use conversion (use rate and land sales) and construction activity (such as planning permissions, construction taxes or taxes on land value improvements), as well as the impact on property tax, the main tax revenue source on a local scale. Note that the local government is not considered here as a benevolent incumbent acting in the public interest but treated as a self-interested strategic player who attempts to maximize its own utility in the form of maximized revenue.

The use of models with strategic interaction is not, however, of recent origin. A strand of the literature has examined the strategic interaction in a tax competition framework, while others have focused on yardstick and welfare competition. All these models generate a reaction function that shows how the decision variable for a given jurisdiction depends on the choices of other jurisdictions.[2]

The evidence on the theoretical and empirical aspects of zoning and how land-use regulations are taken is rich. Brueckner (1995) and Helsley and Strange (1995) are good examples of theoretical papers modeling land-use regulation with strategic interactions among neighboring communities. In particular, these studies model the adoption of growth controls and minimum lot sizes, respectively, to limit urban expansion. Brueckner (1998) uses data on California cities to provide empirical evidence on the existence of policy interdependencies in the adoption of growth controls. To the best of our knowledge, however, no attempts have been made in the literature to analyze spatial interdependencies between competing cities in the selection of zoning policies aimed at promoting (instead of restricting) residential development. In order to further investigate the drivers of local governments behavior, this paper incorporates the interdependence of land-use conversion among neighboring cities by means of reaction functions. A given city is likely to be interacting with many competing cities in the housing market, and the challenge is to allow for such interaction in the empirical specification. To motivate the empirical work, we first develop a simple theoretical model. Then, a Spatial Lag Model is specified so as to empirically account for such interjurisdictional interdependencies in land-use decision-making. The estimation uses data on the amount of land zoned for development and other socio-economic, geographical and political variables for cities in the Madrid metropolitan area over the 2000-2007 period. The results report a positive and significant interaction coefficient.

The reminder of the paper is organized as follows. In the next section we provide an overview of the institutional setting for land-use regulation in Spain. The third section presents a simple theoretical model from which we derive the hypothesis to be tested empirically. In the fourth section we develop the model and describe the data, while the main results are presented in the fifth section. Finally, the sixth section concludes.

[2] See Brueckner (2003) for a survey.

2 Institutional setting

Since 1956, the year when the first Land Use Act was passed, the Spanish urban planning scene has been affected by numerous legislative revisions (González, 2007). Spanish land-use planning has evolved from administrative centralism during the military dictatorship to abundant and complex regional and local urban planning legislations. The Land Use Act of 1956 introduced public intervention in land-use decision-making as a remedy for real estate speculation, and it still represents the basis of current national legislation. In the same vein, the Land Use Act of 1975 led to the decentralization of urban planning to regional and local governments, hence adapting from pre-democratic bodies to the new political and territorial circumstances emanating from the Constitution of 1978. According to this law, the central government would establish the land-use regulation benchmark (as regards the protection of areas designated non-developable), which would be complemented by laws enacted by regions (basic spatial planning guidelines), while local governments would be responsible for passing municipal land-use plans (detailed physical planning). In practice, local authorities enjoyed considerable freedom in determining a municipality's urban planning and ended up controlling the supply of urban land for real estate development. The high political fragmentation (more than 8,000 municipalities) along with a lack of regional coordination led to intense urban development activity. As a result, the traditional compact city model was replaced with randomly spread out suburban development (i.e. suburban housing of a low projected density for middle to high income classes). In 1990, a new Land Use Act was passed with the objective of designing new urban planning strategies for containing urban sprawl while helping urban centers' revive. Various mechanisms were passed, among the most important of which was one of redistributive nature entitled use rate: owners' urban planning use would be 85% of the distribution areas use rate. In other words, urban developers would be under the obligation to hand over a 15% of newly developed land to the local authorities. This land would be incorporated in municipal assets as public land, and local governments would be able to sell this stock of land for the general public interest. The constant increase of housing prices observed during the 90s (accelerating since 1996) motivated a new Land Use Act, which was passed in 1998. This new law led to the liberalization of land use, since an increase in land supply was expected to reduce housing prices. Several changes in land use classification were introduced with the aim of facilitating the conversion of land from rural to urban uses (Fernández, 2008; Bilbao et al., 2006; Roca and Burns, 2000). Nonetheless, it has been argued that the elevated prices that housing reached in Spain prior to the collapse of the housing market in 2007 demonstrate the failure of this governmental policy, which has profited speculating developers by giving them more land on which to build while becoming a treat for sustainability (González, 2007).

2.1 How does the land-use conversion work in Spain?

Spain has experienced rapid urbanization since mid 90s to 2007, when the housing boom took place and the financial crisis started. This explosive urbanization was fueled by rapid conversion of land from rural to urban use, a process facilitated by local governments. In Spain, land is either public or privately owned. According to data provided by the Property Assessment Office, in 2007 21% of non-developable land (rural land) and 42% of developable land (vacant land) in the urban area of Madrid were owned by the government. Nonetheless, the unique characteristic of the planning system in Spain is that, although an individual might own the land, the local government is empowered to control and implement all processes of urban development. Landowners are not permitted to develop their land without the prior agreement of the local administration. The council must declare the land developable and must define precisely the conditions for such development.

The local land-use planning is instrumented via *General*, *Partial* and *Special Land-use Plans*. A local government's *General or Master Plan* classifies the municipality's land into non-developable land (where development is banned, at least until a new plan is passed), developable land (vacant land where future development is allowed) and developed or built-up land; it also establishes the organizational structure of the territory (system of communications) and the system of open spaces and community services. A *Partial Plan* is a more detailed planning document for land use conversion form vacant to developed land. *The Partial Plan* follows the guidelines depicted by the *General Plan* (develops it in new urban areas; regulates the portions of municipal land to be developed) and specifies land zoning (residential, commercial and industrial uses of development), reserves of green areas and public equipment, streets, and the maximum floor-area ratio for each dwelling, among others. A *Special Plan* is required whenever land is converted from rural (non-developable land) to urban uses (vacant land). The Spanish planning system is of hierarchical nature and, as such, any local land-use plan (*General, Partial or Special*) must not contravene regional and national laws.

2.2 What are the benefits/incentives of land-use conversion?

In Spain, as in many other countries, the local provision of public services is financed primarily from local taxes, user fees and the non-earmarked grants that local governments receive from upper tiers of government. Nonetheless, the limited management capacity of local authorities to obtain and handle resources means that many municipalities face financial difficulties when trying to meet their expenditure needs. Thus, a number of local governments maintain the investment levels required to satisfy their residents' demands by relying either on immediate financing derived from urban growth or on transfers from the regional or central government (Hortas-Rico, 2014).

In particular, land-use conversion and expansionary zoning are considered a potential source of finance for municipal governments for the following reasons. First, as aforementioned, vacant land is not ready for development until it is included in a *Partial Plan*. In other words, urbanization requires prior approval of *Partial Plans* to be attached to the *General Plan*. In doing so, urban developers are under the obligation to hand over a portion of newly developed land to the municipality. In particular, owners of developable land must cede the land needed for public roads, green areas and public facilities free of charge, as well as land corresponding to the 15% of the total built-up floor space authorized (or the equivalent in monetary terms). This land will become public land, and the local authority can sell it afterward and use the revenues from land sale to meet their residents' demand for public goods and services. Second, the local government also receives revenues from the taxes levied on the building activity, including construction taxes, building permits and taxes on land value improvements. Third, local tax revenues also increase because of the property tax, the main source of funding at the local level. This tax is assessed in proportion to housing values, and varies according to the class of property (residential, commercial, industrial and vacant) and the location of the asset (i.e. tax rates vary across jurisdictions). Note that the property tax rate is higher on urban than on rural land-uses, even if it is not developed yet. Clearly, this becomes an economic incentive for local governments for land-use conversion from rural to urban uses, even without a clear intention of development. In 2007, taxes associated to the real estate cycle were 26 percent of non-financial local revenues, whereas the property tax revenues represented the 15 percent of total operating budgets. In addition, local governments also benefit from grants received from upper tiers of government. In terms of revenues, in 2007, inter-governmental grants represented 34 percent of local revenues. Around 70 percent of these transfers comes in the form of a formula-based block grant allocated by the central government. This grant is allocated through a population based formula with weights increasing at specific population thresholds. Hence, local governments could benefit from attracting new residents as higher population counts could lead to higher per capita transfers to a given municipality. Also note that, according to the Spanish grant system, a proportion of capital transfers are dependent on the municipality's infrastructure deficit, which in turn is usually induced by urban growth (Hortas-Rico, 2014). Finally, the expropriation of rural land is not a common practice but it could be implemented for a purpose deemed to be in the general interest. The problem arises when this land is converted to urban uses and then sold to private developers at a higher price (bribes and corruption).

2.3 Mobile residents and interjurisdictional competition

According to the *Tiebout* model (Tiebout, 1956), individuals are mobile across jurisdictions and choose their location according to their preferences. Middle and high-income individuals sort themselves in locations endowed with positive amenities such as open space or a pleasant climate. They flee from inner city problems (such as noise, pollution, or congestion) and locate themselves in nearby residential communities where they can enjoy larger single-family housing units in a safer, greener and peaceful environment. In the urban economics literature it has been argued that population growth along with rising incomes and lower commuting costs have facilitated this population shift towards the suburban jurisdictions located around the metropolitan area core (i.e., the Central Business District).[3] In Spain, additional factors such as lower interest rates and an increasing foreign demand for second homes also fueled this process during the 90s. In such a setting, local governments around the metropolitan area core compete to attract those mobile residents to their jurisdictions, which translates into higher tax bases and, thus, higher tax revenues. To do so, they promote construction activity by increasing land-use conversion from rural to urban uses, while enacting expansionary zoning policies for residential development purposes.

The good side of this intergovernmental competition is that individuals fulfill their

[3]The location of suburban development within an urban area is perhaps one of the most important particularities of many Southern European cities, compared to the North-American urban context. Existing empirical evidence highlights the importance of the existing urban fabric in the suburban development processes of Southern European cities, where proximity to the metropolitan urban core (CBD) is crucial.

preferences when they efficiently self-select into different communities. There is, however, a bad side of this process as this strategic interaction among neighboring jurisdictions can generate an inefficient allocation of resources. On the one hand, a non-optimal level of urban land devoted to residential purposes can arise. On the other hand, there are problems related to a system for financing municipal budgets that heavily relies on volatile revenues linked to the real estate cycle.

3 Theoretical framework

In order to investigate interjurisdictional interdependencies in land-use decision-making, consider for simplicity a metropolitan area containing just two cities, 1 and 2. Each city is endowed with an existing stock of urban land (q_1 and q_2, respectively), which is owned privately and can be either developed ($\bar{q}_1$ and $\bar{q}_2$) or developable (s_1 and s_2), such that:

$$q = q_1 + q_2 = \bar{q}_1 + s_1 + \bar{q}_2 + s_2 \tag{1}$$

The inverse demand function of urban land is then defined as $p = D(q)$, where p is the land value. Assume that each local government provides public services (z) proportionally to population:

$$z_1 = \alpha(\bar{q}_1 + s_1) \tag{2}$$

$$z_2 = \alpha(\bar{q}_2 + s_2) \tag{3}$$

The objective function of the local government is the fiscal surplus, which is defined as the difference between revenues from taxes (with t_1 and t_2 denoting the tax rates) and the costs of providing the public service z.

Suppose that local governments only levy a tax on land value in each community, so that tax revenues in city 1 are:

$$t_1(\bar{q}_1 + s_1) \cdot p = t_1(\bar{q}_1 + s_1) \cdot D(\bar{q}_1 + s_1 + \bar{q}_2 + s_2) \tag{4}$$

Also assume that the cost of providing z_1 is a function of the city's endowment of urban land and a vector X_1 of city characteristics, such that:

$$c(z_1) = c(\bar{q}_1 + s_1; X_1), \tag{5}$$

with $c^{'} > 0$ and $c^{''} > 0$

Then the local government's fiscal surplus in city 1 is given by the following expression:

$$\pi_1 = t_1(\bar{q}_1 + s_1) \cdot D(\bar{q}_1 + s_1 + \bar{q}_2 + s_2) - c(\bar{q}_1 + s_1; X_1) \tag{6}$$

The city chooses s_1, the amount of land to be developed, to maximize (6). Differentiating expression (6) with respect to s_1, the first-order condition for the choice of s_1 is:

$$\frac{\partial \pi_1}{\partial s_1} \equiv \theta_1 = t_1 \cdot D + t_1(\bar{q}_1 + s_1) \cdot D^{'} - c^{'} = 0 \tag{7}$$

And the second-order condition is:

$$\frac{\partial \theta_1}{\partial s_1} = 2t_1 \cdot D^{'} + t_1(\bar{q}_1 + s_1) \cdot D^{''} - c^{''} < 0 \tag{8}$$

Because s_2 appears in D and $D^{'}$, the choice of s_1 depends on s_2, and the effect of s_2 will be given by:

$$\frac{\partial \theta_1}{\partial s_1} ds_1 + \frac{\partial \theta_1}{\partial s_2} ds_2 = 0 \tag{9}$$

$$\frac{ds_1}{ds_2} = -\frac{\delta \theta_1}{\delta s_2} / \frac{\delta \theta_1}{\delta s_1} = -t_1(D^{'} + (\bar{q}_1 + s_1) \cdot D^{''}) / \frac{\partial \theta_1}{\partial s_1} \tag{10}$$

Where $\frac{\partial s_1}{\partial s_2} >< 0$ as $(D^{'} + (\bar{q}_1 + s_1) \cdot D^{''}) >< 0$, which means that the reaction function of city 1 can have either slope.

Note that fiscal surplus could start at zero with a balanced government budget when $s_1 = 0$, such that:

$$\pi_1 \left|_{s_1=0}\right. = 0 \tag{11}$$

When $\pi_1 \left|_{s_1=0}\right.$ is positive, development raises fiscal surplus, which reaches a maximum at the s_1 value where (7) holds. Having started at zero, π_1 is then positive, indicating that the government runs a surplus. Since the surplus must be returned to voters, the government can reduce t_1 until the surplus is once again zero.

4 Empirical analysis

4.1 Econometric strategy

The model in section 3 suggests that city 1's supply of developable land depends on the amount of development s_2 chosen by the competing city 2. Empirically, however, the interaction phenomenon cannot be this simple. A given city is likely to interact with many competing cities in a regional housing market, and the challenge is to allow for such interaction in the empirical specification. Spatial econometrics provides an ideal tool kit to addres the strategic behavior on land use conversion. In particular, in the spatial econometrics framework, a specification such that is known as the *Spatial Lag Model*:

$$y = \alpha \iota_n + \rho W y + X\beta + \upsilon \tag{12}$$

where y denotes a $N \times 1$ dimensional vector consisting of observations on the dependent variable for every unit in the sample $i = 1, 2, ..N$, ι_n is an $N \times 1$ vector of ones associated with the constant term parameter α, X is an $N \times K$ matrix of explanatory variables with associated response parameters β contained in a $K \times 1$ vector, and $\upsilon = (\upsilon_1, ..., \upsilon_N)^{'}$ is a vector of i.i.d disturbances whose elements have zero mean and finite variance σ^2. W is a $N \times N$ matrix of known constants describing the spatial arrangement of the municipalities in the sample, where the diagonal elements are set to zero by assumption, since no municipality can be viewed as its own neighbor, and ρ is the spatial autoregressive coefficient which measures the intensity of interaction between location pairs, as it captures (endogenous) spatial effects working through the spatial lag of the dependent variable Wy.

The modeling strategy in the spatial econometrics literature is under revision, although the standard approach is to start with a non-spatial linear regression model and then test whether or not the model needs to be extended with spatial interaction effects (Elhorst, 2010). Thus, we first estimate the non-spatial model by Ordinary Least Squares (OLS) and test whether the Spatial Lag model or the Spatial Error model is more appropriate describing the data. For this purpose, we use the classic Lagrange Multipliers tests on estimated residuals (LM-tests) and their robust versions. These tests reinforce the theoretical assumption designating that the preferred specification is the Spatial Lag model presented in equation (12)[4] . Also note that we first estimate the model through Maximum Likelihood (ML) but specification diagnostics (Kiefer-Salmon test) determine that residuals are not normal, indicating that a robust method such as instrumental variables (IV) techniques (in particular, Spatial Two Stage Least Squares, S2SLS hereinafter) needs to be implemented.

Finally, the estimation of the spatial model described above requires prior definition of a spatial weights matrix. We consider a matrix based on the concept of first order contiguity, according to which $w_{ij} = 1$ if regions i and j are physically adjacent and 0 otherwise. [5]

4.2 Sample and data

The empirical analysis conducted here is based on the set of municipalities that belong to the urban area of Madrid. We closely follow the methodology proposed by Boix *et al.* (2012) to classify functional metropolitan areas , according to which one can identify 545 municipalities in the metropolitan area of Madrid (from 6 different provinces: Madrid, Toledo, Guadalajara, Ávila, Segovia, Cuenca)[6].

As for the time period covered, it is important to notice that in Spain, as in the rest of Europe, the annual rate of change in land-cover type (from rural to urban uses)

[4]Robust LM Lag = 22.4904, p-value = 2.112e-06; Robust LM Error = 3.6395, p-value = 0.05642

[5]As a robustness check, we also considered several matrices based on the k-nearest neighbours ($k = 1, 2, .., 10$) computed from the great circle distance between the centroids of the various regions, yielding to similar results. As can be seen, both types of matrices are based on the geographical distance between the sample regions, which in itself is strictly exogenous. All the matrices are row-standardized, so that it is relative, and not absolute, distance which matters.

[6]Madrid has been excluded from the sample.

Table 1: Definitions and sources of the variables

Variable	Definition	Source
Dependent Variables		
ΔUrban Land	[(Developable land 2007+built-up land 2007) -(Developable land 2000 + built-up land 2000)/built-up land 2000]x 100	Property Assessment Office
Control variables:		
Vacant Land.	[Developable land 2000 / buil-up land 2000]x 100	Property Assessment Office.
Population size	Total resident population in 2000	Census of Population and Housing, 2000 (INE)
% Aged 25-45	[Population between 25 and 45 years old in 2000 / Total resident population in 2000]x 100	Census of Population and Housing, 2000 (INE).
% Aged +65	[Population over 65 years old in 2000 / Total resident population in 2000]x 100	Census of Population and Housing, 2000 (INE).
% Manufacturing	[Employed in manufacturing in 2000 / Employment 2000]x 100	Census of Population and Housing, 2000 (INE).
Income	Per capita income in euros	Own calculations and TAO
% Graduates	[Population with college degree in 2000 / Total resident population in 2000]x 100	Census of Population and Housing, 2000 (INE)
Left [(1)].	Dummy=1 if the major belongs to a left party during the 1999-2002 term, 0 otherwise.	Ministry of Home Affairs.
Maximum temperature [(2)]	Maximum average temperature	Ministry of Agriculture, Food and Environment.
Precipitation	Mean annual precipitation	Ministry of Agriculture, Food and Environment.
Terrain ruggedness index (m)[(3)]	Municipal average value of the terrain ruggedness index developed by Riley et al (1999)	National Geographic Institute and GIS.
Elevation range (m)	Elevation range for each municipality	National Geographic Institute and GIS.
Distance to road (km)[(4)]	Average distance from municipality centroid to the nearest main or secondary road 18th century	GIS
Distance to central city (km)	Average distance of each municipality's centroid to the centroid of Madrid.	GIS

Notes:physical geography variables and other relevant distance measurements have been calculated using Geographical Information Systems (GIS). All data is at the level of municipality. INE denotes the Spanish National Institute of Statistics. (1) Parties on the left are: PSOE, PCE, IC, and several left regionalist parties.(1) The type of problems considered are noise, dirty, pollution or lack of green space. (2) Maximum temperatures and average precipitation are calculated from the climatic normals for individual weather stations from the National Weather Service (monthly climate data, 2000). (3) This index has been calculated using the Spanish 200-meter digital elevation grid to give a summary statistic of differences in meters of elevation between points 200-meters apart. (4) In order to avoid endogeneity problems due to reverse causation, a historical road map (main and secondary roads constructed before the end of the 18th century) has been used as a source of exogenous variation for the definition of the variable.

peaked during the 1990s and continued until the housing market collapsed in 2007. Indeed, 30 percent of the artificial surfaces in existence today were created during the nineties and the begining of 2000s (EEA, 2006).

Hence, the strategic behavior of local governments in land-use decision-making can be examined by estimating the regression equation given by expression (12), where y represents the vector consisting of observations on the additional amount of land assigned for new development for every municipality in the sample between the years 2000 and 2007, computed as the ratio of the previous built-up land area ($\Delta urbanland$). As stated above, the variable Wy denotes the endogenous interaction effects among the dependent variables, and the coefficient on this competing variable (ρ) measures the strength of the dependence between municipality pairs. This autoregressive parameter indicates how a given city responds to the level of land-use conversion in nearby jurisdictions, giving the slope of its reaction function. A non-zero coefficient indicates that these choices are interdependent across cities, and strategic interaction occurs, whereas a zero coefficient means that strategic interaction is not present. In such situations, one city's urban land choice is unaffected by the choices of neighbors. X denotes a matrix of observed municipality's characteristics in the initial year (2000) expected to influence differences in the amount of land converted from rural to urban uses (see definitions and data sources in Table 1), with associated parameters β. The control variables that fill out matrix X include, on the one hand, the vacant land in each municipality, defined as the amount of land assigned for development which remains vacant at the beginning of the period of study (in 2000) as a proportion of previous built-up or developed land (*vacant land*). X also includes other control variables, measuring either the effect of the demand pressures, residents' preferences or the disamenity effects of growth. This set includes measures of local socio-economic factors and employment shocks (*population size, %Aged25-40, %Aged65, per capita income, %graduates,%manufacturing*); variables that account for the amenity factors deemed important for location decisions (*maximum temperature, average precipitation, road accessibility, distance to Madrid*); natural barriers that either constrain or promote urban development (*terrain ruggedness index, elevation range*); and a variable related to the political ideology of the local incumbent and his preferences for development (*left*).

5 Main results

The results of the ML and S2SLS estimation of the model given by expression (12) are presented in Table 2. To aid comparison across variables, all variables are expressed in logarithms so that reported estimated coefficients can be interpreted as elasticities.

Non-spatial linear regression parameters provide consistent estimates of the marginal impacts of explanatory variables on the dependent variable, which are identified with the partial derivative of the dependent variable relative to the explanatory variable. But models containing spatial lags of the dependent variable require special interpretation of the parameters, as spatial regression models expand the information set to include information from neighbouring regions/observations. In such cases, the total derivative would be the combined effect of all dependent variable changes in the simultaneous equilibrium, as a change in the explanatory variable for a single region/observation can potentially affect the dependent variable in all other observations/regions (*spillover effects*). This impact includes the effect of feedback loops where observation i affects observation j and observation j also affects observation i as well as longer paths which might go from observation i to j to k and back to i (LeSage and Peace, 2009). Thus, the spatial lag model estimate of β obtained after spatially filtering the dependent variable is a consistent estimate of the direct, or marginal, impact of X on y in the equilibrium for the system. Column (1) of Table 2 presents the OLS results; Column (2) presents the estimated coefficients, direct and indirect impacts of the ML estimation of the spatial lag model; Column (3) presents the estimated coefficients, direct and indirect impacts of the S2SLS estimation of the spatial lag model. Estimated coefficients and indirect impacts presented here are just informative, but for the reminder of the paper only the post-estimation summary measures of the so-called *direct impacts* will be discussed.

The most important finding from Table 2 is that the estimated interaction coefficient (Wy) is positive and statistically significant at well over a 99 percent confidence level, and occurs with a magnitude of around 0.11 regardless of which estimation method or weighting scheme is considered. This finding provides evidence of spatial interaction in the land use conversion decisions between neighbouring municipalities. A local government's decision on the additional amount of land assigned for new development is positively influenced by the decisions of neighbouring jurisdictions, with other causal factors remaining constant. This result could suggest that local incumbents do not make land-use policy decisions in isolation but rather imitate nearby local incumbents when selecting zoning policies aimed at promoting residential development.

We now consider the impact of the control variables. In general, all variables considered have the expected sign and are consistent with a priori expectations derived from urban economics theory, although a few of them turn out to be not statistically significant. First, the vacant land in each municipality has a clearly positive and significant impact on the amount of additional land assigned for new development. Then, a 1 per cent increase in vacant land increases new urban development by around 0.44 per cent.

Second, the effect of demand increases and employments shocks are proxied here with a set of local socio-economic variables. The results provide evidence of a positive effect of total local population and the percentage of young population on urban development (with coefficients of around 0.76 and 0.17, respectively). As expected, differences in the economic base of municipalities in a given urban area influence its geographical footprint. Specifically, the greater the presence of manufacturing (an employment sector whose economics drive it to locate in more densely populated central places in urban areas to benefit from agglomeration economies), the higher the additional amount of new land devoted to urban development. A one percent increase of local population employed in manufacturing increases urban growth by 0.05 percent. The income variable also plays an important role in explaining local urban development. In particular, richer jurisdictions tend to exhibit decreasing urban development, as the coefficient is negative and statistically significat with a magnitude of around 0.92. This result is in line with the literature, as richer communities tend to avoid additional urban development in their neighborhooods.

Third, we consider the amenity factors deemed important for location decisions. As expected, those locations with better road accessibility (i.e. with shorter average distance from the city center of the municipality to main and secondary roads) would experience higher urban development, although the impact of this variable is not statistically significant. This result is in line with a growing body of the literature has focused on the influence of transportation system improvement and availability of roads on urban growth. In additon, climate is also crucial in explaining land use conversion rates. Extreme climate conditions (high maximum temperatures) have a negative and statistically significant effect on additional urban development. In the

Table 2: Estimation results

	Robust OLS	**Spatial Lag ML**			**Spatial Lag S2SLS**			**Descrip. stat.**	
	Estimated parameters	Estimated parameters	Direct Impacts	Indirect Impacts	Estimated parameters	Direct Impacts	Indirect Impacts	Mean	Std.Dev.
Spatial dependence:									
Rho	–	0.1348***			0.1063***				
Control variables:									
% Vacant Land	0.441***(0.047)	0.441*** (0.038)	0.443***	0.066***	0.441*** (0.039)	0.442***	0.035	82.29	123.15
Population size	0.768***(0.039)	0.753*** (0.038)	0.756***	0.114***	0.759*** (0.038)	0.761***	0.061	4,085,22	16,505.63
% Aged 25-45	0.180** (0.078)	0.171** (0.085)	0.171**	0.025	0.174** (0.086)	0.175**	0.014	20.75	7.15
% Aged +65	-0.019 (0.131)	0.024 (0.127)	0.024	0.004	0.005 (0.130)	0.005	0.001	31.21	16.98
% Manufacturing	-0.055 (0.035)	0.053* (0.030)	0.053*	0.008	0.054* (0.030)	0.054*	0.004	14.36	9.68
Income pc	-0.923***(0.263)	-0.923*** (0.276)	-0.927***	-0.140**	-0.923*** (0.282)	-0.924***	-0.075	10,526.43	2,038.80
% Graduates	0.233***(0.056)	0.234*** (0.042)	0.235***	0.035***	0.234*** (0.043)	0.234***	0.019	6.79	5.17
Left	-0.195** (0.079)	-0.161** (0.076)	-0.161**	-0.024*	-0.176** (0.078)	-0.176**	-0.014	0.44	0.49
Maximum temperature	-1.669** (0.675)	-1.114 (0.781)	-1.118	-0.168	-1.355* (0.799)	-1.357*	-0.110	42.02	12.32
Precipitation	-0.388 (0.251)	-0.359 (0.285)	-0.361	-0.054	-0.372 (0.290)	-0.372	-0.030	42.02	12.32
Terrain ruggedness index	0.078** (0.039)	0.090** (0.041)	0.090**	0.013*	0.085** (0.042)	0.085**	0.006	4.766	5.252
Elevation range	-0.491**(0.209)	-0.351 (0.218)	-0.317	-0.047	-0.392* (0.221)	-0.392*	-0.031	0.89	0.25
Road accessibility	-0.044 (0.029)	-0.031 (0.031)	-0.031	-0.004	-0.036 (0.032)	-0.036	-0.003	6.37	6.23
Distance to central city	-0.246 (0.150)	-0.092 (0.147)	-0.093	-0.014	-0.159 (0.154)	-0.159	-0.012		
Constant	17.194***(4.575)	11.962**(4.921)			14.232***(5.119)				

Notes: The dependent variable is the additional amount of land assigned for new development between the years 2000 and 2007, computed as the ratio of the previous built-up land area, with mean 170.98 and standard deviation 288.37. Coefficients give the impact on the dependent variable of one-standard-deviation increase in the corresponding variable. Column (1) reports the robust OLS results. Column (2) reports the Maximum Likelihood spatial lag results. Column (3) reports the S2SLS results for the spatial lag specification. Numbers in brackets report standard errors (heteroskedastic-consistent version in the OLS and S2SLS estimations). ***, ** and * indicate significance at the 1 percent, 5 percent and 10 percent level, respectively.

same vein, rainy locations are less valued by individuals and hence will experience less increases in the amount of land devoted to new urban development, although this variable turns out to be not statistically significant. Fourth, we test the hypothesis that natural barriers can either promote or constrain development. As expected, the presence of mountains (measured here with the elevation range) limits urban expansion, as they make development more costly. This variable has the expected effect, providing compelling evidence that physical geography does exert an influence on urban development. Specifically a one percent increase in the elevation range decreases urban development by 0.4 percent. In contrast, small-terrain irregularities (terrain ruggedness index) have the opposite effect, as hillsides where development is more costly alternate with flat portions where development is less costly. Thus, a one percent increase in this index increases the amount of additional land devoted to urban development by 0.08 percent. The proximity to the central city of the metropolitan area (Madrid) was considered important for local governments development strategies, but this variable is not statistically significant.

Finally, the left government dummy, included in the model to account for the influence of politics on land-use decision-making, has a negative and significant effect, indicating that locations that belong to a left party experience less land use conversion devoted to urban development than those where a right-wing party is present, all else equal. This result is consistent with previous empirical studies where parties to the right of the political spectrum are expected to allow more land to be developed, thus promoting more urban development.

6 Concluding remarks

A long line of research in economics analyzes the factors that shape local zoning and land-use regulations, as they can influence the amount, location and shape of urban development and even affect land rents, housing prices, environmental quality, transportation costs, and labor markets. Thus far, however, theoretical and empirical research has focused on zoning and land-use regulations as tools to limit urban expansion, whereas no attempts have been made in the literature to analyze spatial interdependencies between competing cities in the selection of zoning policies aimed at promoting (instead of restricting) residential development.

In a *Tiebout* setting where middle and upper income residents shop among rival nearby locations, local governments will compete to attract those mobile residents to their jurisdictions, as it translates to broader tax bases and higher tax revenues. This competition becomes particularly relevant in an environment where local authorities have limited fiscal capacity and a limited set of tax instruments to raise revenues. This being the case, land use conversion for residential uses becomes an important source of finance for local governments, as land-based financing has the biggest payoff where there is rapid urban growth.

In order to further investigate the drivers of local governments behavior, this paper incorporates the interdependence of land-use conversion among neighboring cities by means of reaction functions. A given city is likely to be interacting with many competing cities in the housing market, and the challenge is to allow for such interaction in the empirical specification. A simple theoretical model has been derived and then tested empirically with data on the municipalities within the metropolitan area of Madrid (Spain) for the 2000-2007 period. The empirical evidence support the main hypothesis derived from the theoretical model, as we find a positive and significant effect of the interaction coefficient. That is, it seems that local governments do not take their land-use decisons on isolation but rather take into account decisions made by nearby jurisdictions.

Overall, results presented here suggest that local authorities need to be aware of the social and economic implications of their land-use decision making, as this strategic interaction among neighboring jurisdictions can generate an inefficient allocation of resources. A system for financing municipal budgets that heavily relies on volatile revenues linked to the real estate cycle has numerous perils and affects the efficient provision of public goods and services. This being the case, a policy reform regarding the design of the local finance system and restructuring of grants received from upper tiers of governments is required in order to limit undesired and inneficient urban development.

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