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Expansionary zoning and the strategic behavior of local governments. Evidence from Spain

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Expansionary zoning and the strategic behavior of local governments. Evidence from Spain

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Abstract. This paper analyzes the extent to which 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 Spanish municipalities from 2003 to 2011, we report evidence in support of this hypothesis. The results suggest that local incumbents do not make policy decisions in isolation: reaction functions arise because the mobile tax base reacts to the regulatory measures that modify land uses in the municipality, leading to an inneficient excess of land devoted to urban development.

Keywords: local land supply, land-use conversion, redidential development, local governments, spatial econometrics.
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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 by Gyourko and Molloy (2015), 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 and 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 several 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 revenue[1].

[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 that attempts to maximize its own utility in the form of maximized revenue.

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. If this is the case, land use conversion for residential uses becomes an important source of financing for local governments, as it has the biggest payoff where there is rapid urban growth. The use of models with strategic interaction is not, however, of recent origin. A strand of the literature has examined strategic interaction related to spillover benefits, or in a tax competition framework, while others have focused on yardstick and welfare competition. All these models generate a reaction functions that show 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 interact 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 model is specified 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 Spanish cities over the 2003-2011 period. The results report a positive and significant interaction coefficient.

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

The reminder of this 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 the paper.

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-Pérez, 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 (regarding 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 to revive urban centers. Various mechanisms were passed, among the most important of which was one with an entitled use rate of a redistributive nature: owners' urban planning use would be 85% of the distribution area’s use rate. In other words, urban developers would be under the obligation to hand over 15% of newly developed land to the local authorities. This land would be incorporated into 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 in housing prices observed during the 1990s (accelerating since 1996) motivated a new Land Use Act, which was passed in 1998. This new law led to the liberalization of land use because 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 not enhancing sustainability (González-Pérez, 2007).

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

Spain has experienced rapid urbanization from the mid-1990s to the end of 2000s when the housing boom took place and the financial crisis started. This explosive urbanization was fueled by the rapid conversion of land from rural to urban use, a process facilitated by local governments. In Spain, land is either public or privately owned. 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 council, that must declare the land developable and must precisely define 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 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 from vacant to developed land. The Partial Plan follows the guidelines depicted by the General Plan (develops it into 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 other factors. 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 a 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 financing 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 sales 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 for urban than on rural land uses, even if the land 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 addition, local governments also benefit from grants received from upper tiers of government. Approximately 70 percent of these transfers come 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. A 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 more 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

[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

interest rates and an increasing foreign demand for second homes, also fueled this process during the 1990s. In such a setting, local governments around the metropolitan area can 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 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 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

$$q = q_1 + q_2 = \bar{q}_1 + s_1 + \bar{q}_2 + s_2 \quad (1)$$

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:

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

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

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.

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development processes of Southern European cities, where proximity to the metropolitan urban core (CBD) is crucial.

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

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

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:

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

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

$$\frac{\partial \pi_1}{\partial s_1} \equiv \theta_1 = (t_1) \cdot D(\bar{q}_1 + s_1 + \bar{q}_2 + s_2) + (t_1\bar{q}_1 + t_1 s_1) \cdot D'(\bar{q}_1 + s_1 + \bar{q}_2 + s_2) - c'(\bar{q}_1 + s_1; X_1) = 0 \tag{7}$$

And the second-order condition is

$$\frac{\partial \theta_1}{\partial s_1} = (2t_1) \cdot D'(\bar{q}_1 + s_1 + \bar{q}_2 + s_2) + (t_1\bar{q}_1 + t_1 s_1) \cdot D''(\bar{q}_1 + s_1 + \bar{q}_2 + s_2) - c''(\bar{q}_1 + s_1; X_1) < 0 \tag{8}$$

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

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

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

where $\frac{\partial s_1}{\partial s_2} \gtrless 0$ as $(D' + (\bar{q}_1 + s_1) \cdot D'') \gtrless 0$, 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

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

When $\left.\frac{\partial \pi_1}{\partial s_1}\right|_{s_1=0}$ is positive, development raises the fiscal surplus, which reaches a maximum at the s_1 value where (7) holds. Having started at zero, expression (11) is then positive, indicating that the government runs a surplus. Because the surplus must be returned to voters, the government can reduce t_1 until the surplus is once again zero.

4. 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 is not that 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 the empirical literature on strategic interaction among local governments, endogenous interaction effects are theoretically consistent with the situation where taxation and expenditures on public services interact with taxation and expenditures on public services in nearby jurisdictions (Brueckner, 2003). Reaction functions have been estimated mainly for taxes, although an increasing number of contributions deal with reaction functions for public expenditures. Most papers rely on the spatial lag specification (SAR), which is theoretically consistent with three different sources of strategic interaction: (i) the spillover model, (ii) the resource flow or tax/welfare competition model, and (iii) the yardstick competition model (Brueckner, 2003). In many cases, it is not immediately clear whether substantive spatial dependence stems from one of these models, or a combination of them. The *expenditure spillover model* states that, as local public services can have beneficial or detrimental effects on nearby jurisdictions, an agent chooses the level of the strategic variable observing directly on other agents decisions. The *resource-flow model* argues that agents' strategic decisions are affected by the amount of certain resource availability, and because the distribution of such resource depends on the decisions of the rest of the agents, each agent's decision on the strategic variable are indirectly influenced by decisions of all other agents. The *political yardstick competition model* determines that voters use information from other jurisdictions to judge the performance of their own politicians. The reason for this behavior is that voters do not know what level of services can be provided relative to a certain tax level. Since tax rates in nearby communities are easily observed, they can serve as a benchmark. If voters consider relative performance, rational politicians will do the same and mimic their neighbors' decisions.

In our context, a local government does not care directly about the amount of converted land levels of other local governments but about the amount of residents that can be attracted to its jurisdiction. Accordingly, the strategic-interaction theoretical framework that best describes our model is the *resource-flow* explanation. The distribution of residents among jurisdictions is affected by the converted land choices of all local governments. Therefore, each local government is indirectly affected by other neighboring local governments' decisions. According to the tax (or welfare) competition theory, a tax (welfare) reaction function arises because the tax base is mobile and reacts to local tax rate (welfare) differentials. This procedure results in an inefficient race to the bottom of tax rates (welfare programs). In our setting, the mobile tax base reacts to the regulatory measures that modify land uses in the municipality. The result is an excess of land devoted to urban development.

Given the above, we rely on theory and define a SAR model as our baseline specification to empirically confirm the existence of strategic interaction effects among nearby jurisdictions and whether they relate to the *resource-flow theory*. Two different modeling strategies can be adopted to test the existence of governments' interdependencies interactions. On the one hand, the *specific-to-general approach* estimates a non-spatial linear regression model and then tests whether the model needs to be extended with spatial interaction effects (Elhorst, 2010). On the other hand, the *general-to-specific-approach* starts estimating a general model including the spatial lags of the dependent variable, the independent variables and the residuals and then test if any of them is not significant. Mur and Angulo (2009) carries a simulation exercise to identify the correct model specification and determine that under all standard assumptions both strategies produce hardly distinguishable results. However, the *general-to-specific* approach produces better results when distortions, such as non-normality in the errors or heteroskedasticity with a spatial pattern, are introduced into the data generation process (DGP). On the other hand, the impact of endogeneity on the explanatory variables seems to be more acute in the *general-to-specific* approach.

Specification diagnostics determined the existence of heteroscedasticity and the absence of normal distributed disturbances[4]. Therefore, we implement the *general-to-specific* approach and estimate the model through spatial heteroscedastic consistent procedures (HAC)[5]. This approach starts estimating a general model including the spatial lags of the dependent variable, the independent variables and the residuals and tests if any of them is not significant. The extended model reads as

$$\begin{aligned} \boldsymbol{y} &= \alpha\boldsymbol{\tau_N} + \boldsymbol{\rho W y} + \boldsymbol{X}\,\boldsymbol{\beta} + \boldsymbol{W X \gamma} + \boldsymbol{\epsilon} \\ \boldsymbol{\epsilon} &= \boldsymbol{\lambda W \epsilon} + \boldsymbol{\varphi} \end{aligned} \qquad (12)$$

where $\boldsymbol{y}$ represents the N-dimensional vector consisting of one observation on the dependent variable for every unit in the sample $(i = 1, \ldots, N)$, $\boldsymbol{\tau_N}$ is an $Nx1$ vector of ones associated with the constant term parameter α, $\boldsymbol{X}$ denotes an NxK matrix of explanatory variables, with associated (fixed but unknown) parameters $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ contained in a $Kx1$ vector, respectively. $\boldsymbol{\epsilon}$ is a vector of first-order autocorrelated disturbance terms and $\boldsymbol{\varphi} = (\boldsymbol{\varphi}_1, \ldots, \boldsymbol{\varphi}_N)'$ is a vector of independently identically distributed (i.i.d.) disturbance terms with zero mean and non-constant variance σ_i^2, while $\boldsymbol{\lambda}$ is the spatial autocorrelation coefficient.

$\boldsymbol{W}$ is a NxN matrix of known constants describing the spatial arrangement of the municipalities in the sample, where the diagonal elements are set to zero by assumption because no municipality can be viewed as its own neighbor. The values of the w_{ij}'s reflect prior expectations regarding the spatial patterns of interaction. The variable $\boldsymbol{Wy}$

[4] The Kiefer-Salmon test (KS = 0.543, p-value < 2.2e-16) determines that OLS residuals are not normal and the Koenker Baset test (BP = 97.4217, df = 20, p-value = 3.63e-12) confirms the presence of heteroskedasticity. Arrainz et al (2010) provides simulation evidence that when the innovations are heteroskedastic, ML produces inconsistent estimates.

[5] The *specific-to-general approach* has also been tested, yielding to similar results. We estimated the model implementing the 2SLS estimation method correcting for heteroskedasticity with two different robustness corrections: a white consistent estimator and a Generalized Least Square estimator of the variance-covariance matrix. Changes in the estimated variance covariance matrix did not lead to large changes in the direct and indirect effects.

denotes the endogenous interaction effects among the dependent variables (i.e. the spatial lag), $\boldsymbol{WX}$ the exogenous interaction effects among the independent variables, and $\boldsymbol{W\epsilon}$ the interaction effects among the disturbance terms of the different spatial units. Finally, $\boldsymbol{\rho}$ is the coefficient that measures the intensity of interaction between location pairs. Given that we only expect to observe spatial interaction between neighbouring municipalities, the binary queen contiguity matrix becomes appropriate to capture the phenomenon.

Manski (1993) notes that at least one interaction effect must be excluded because otherwise the parameters are unidentified. When a global spillover specification can be theoretically justified for the process, as we hypothesized in our *resource flow* theoretical model, we should estimate the SDM which assumes $\boldsymbol{\lambda} = \boldsymbol{0}$ (Lesage, 2014)**.** Given that the estimations are based on the general method of moments and the structuring of the GS2SLS (and equivalent heteroskedastic version), it makes it effectively impossible to fit a SDM[6], so the most general model that can be estimated to test the significance of our parameter of interest ($\boldsymbol{\rho}$) is the SAC model, where $\boldsymbol{\gamma} = \boldsymbol{0}$[7].

The spatial HAC estimator is robust against possible misspecification of the disturbances and allows for (unknown) forms of heteroskedasticity and correlation across spatial units[8]. Hence, we estimate the SAC model through the GS2SLS estimation method assuming that the disturbance vector is generated by a very general process (Piras, 2010):

$$\boldsymbol{y} = \alpha\boldsymbol{\tau_N} + \boldsymbol{\rho W y} + \boldsymbol{X\beta} + \boldsymbol{\varepsilon}\,; \qquad \boldsymbol{\varepsilon} = \boldsymbol{R\theta} \tag{14}$$

where $\boldsymbol{\theta}$ is a vector of innovations and $\mathbf{R}$ is a NxN non-stochastic matrix the elements of which are not known[9].

4.2. Sample and data

The empirical analysis conducted here is based on a set of Spanish

[6] Even if one tries (using higher lags by hand), the results are typically numerically unstable.
[7] Nevertheless, we estimate the SDM through ML and the Likelihood Ratio test statistics point towards a SAR specification. These results are available upon request to the authors.
[8] Nonetheless, even if we assume such a general specification for the disturbance process we still have to be concerned about possible misspecifications (e.g., due to an incorrect specification of the weights matrices).
[9] We test the robustness of the model specification to different Kernel functions, and also compare the coefficients significance to the results obtained with the robust estimator to those obtained under the non-robust standard errors.

municipalities for the period 2003-2011. The data sample is restricted to municipalities above 1,000 inhabitants due to the lack of socio-economic and political data for those localities below this threshold. This leads to a final sample of 2,543 observations, which we believe to be representative of the whole population.

As for the time period covered, the analysis covers two terms-of-office, i.e. 2003-2007 and 2008-2011, because of the lapse of time between the decision is made, the land is converted and then finally developed. In addition, it is important to note that, in Spain, as in the rest of Europe, the annual rate of change in land-cover type (from rural to urban uses) 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 1990s and the beginning of the 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 (14), where $\boldsymbol{y}$ represents the vector consisting of observations of the additional amount of land assigned for new development for every municipality in the sample between the years 2003 and 2011, computed as the ratio of the previous built-up area (developed land). As stated above, the variable $\boldsymbol{Wy}$ denotes the endogenous interaction effects among the dependent variables, and the coefficient on this competing variable, $\boldsymbol{\rho}$, 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, creating 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. $\boldsymbol{X}$ denotes a matrix of observed municipality characteristics in the initial year (2000) expected to influence differences in the amount of land converted from rural to urban uses (see definitions, data sources and expected effects in Table 1), with associated parameters $\boldsymbol{\beta}$. The control variables that fill out matrix $\boldsymbol{X}$ include, on one hand, the vacant land in each municipality, defined as the amount of land assigned for development that remains vacant at the beginning of the period of study (in 2003) as a proportion of previous built-up or developed land (*vacant land*). $\boldsymbol{X}$ 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, % Aged 25-40, per* *capita income, homeownership rate, % employed, blight*); variables that account for the amenity factors deemed important for location decisions *(%open land, % forests*, road accessibility – proxied by the variables *vehicles per household, distance to main roads* and *road density* -, and *distance to the coast*); natural barriers that either constrain (*elevation range, water bodies*) or promote urban development (*terrain ruggedness index*, *inland water*); and two variables related to the political ideology of the local incumbent and his preferences for development (*dleft, dmajority*). Finally, a dummy variable that accounts for the fact that a municipality is a suburb within a given metropolitan area has also been included (*dSuburb*)[10].

[10] We closely follow the methodology proposed by Boix et al. (2012) to classify functional metropolitan areas, according to which one can identify 62 urban areas. Then, all municipalities within a metropolitan area that are not the central city are considered as suburbs.

Table 1: Definitions, data sources and expected effects of the variables

Variable	Definition	Source	Expected effect
Dependent variable			
Δ Urban Land	[(Developable land 2011 + Built-up land 2011) - (Developable land 2003 + Buil-up land 2003) / Built-up land 2003] x 100	Property Assessment Office	
Control variables			**Expected effect**
Vacant land (%)	[Developable land 2003 / Built-up land 2003] x 100	Property Assessment Office	-
Income	Personal income in euros, 2003 (in logs)	Spanish Tax Administration and own calculations.	-
Homeownership rate	[Houses occupied by owner 2001 / Houses 2001] x 100	Census of Population and Housing. Spanish National Institute of Statistics.	-
% Employed in manufacturing	[Employed in manufacturing in 2001 / Employment 2001]x100		+
Population	Total resident population in 2003 (in logs)		+
% Aged 25-45	[Population between 25 and 45 years old in 2003 / Total resident population in 2003]x100		+
Open Land (%)	[Total land area of the municipality - Built-up land 2003 / Built-up land 2003] x 100	Corine Land Cover	+
Forest (%)	[Forest and agricultural area (including vineyards, rice fields, friut trees plantations, olive groves, etc) / Total land area] x 100		+
Distance to the coast (km)	Distance from municipality centroid to the nearest coast		-
Road density (km/pop)	[Kilometers of roads (main and secondary roads 2000) / Total resident population in 2000]		+
Distance to road (km)	Distance from municipality centroid to the nearest main or secondary road		-
Vehicles per household	Average number of vehicles per household in 2001		+
Blight (%)	[Houses with problems related to noise, dirty, pollution or lack of green space, as of 2001 / Houses in 2001] x 100		-
Terrain ruggedness index (km)	Municipal average value of the terrain ruggedness index developed by Riley et al (1999), calculated on the 200-meter elevation grid to give a summary statistic of differences in meters of elevation between points 200-meters apart.	National Geographic Institute and GIS (own calculations).	+
Elevation range (km)	Elevation range for each municipality		-
Water bodies (%)	[Wetlands and oceans' area / Total land area]x100		-
Inland water (%)	[Inland waters / Total land area]x100		+
dSuburb	Dummy =1 if the municipality belogs to a metropolitan area but it is not the central city.	Boix et al (2012)	+
dLeft	Dummy =1 if the major belongs to a left party during the 2003-2007 term, 0 otherwise. Parties on the left are: PSOE, PCE, IC, and several left regionalist parties.	Spanish Ministry of Home Affairs. Municipal elections in 2003.	-
dMajority	Dummy =1 if the party of the major has a majority of seats in the local council, 0 otherwise.		+

Notes: physical geography variables and other relevant distance measurements have been calculated using Georaphical Information Systems (GIS). All data is at the level of municipality.

5. Main results

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. However, 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 neighboring 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 jurisdiction can potentially affect the dependent variable in all other jurisdictions (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 that might go from observation i to j to k and back to i (LeSage and Peace, 2009). Thus, the spatial lag model estimate of $\boldsymbol{\beta}$ obtained after spatially filtering the dependent variable is a consistent estimate of the direct or marginal impact of $\boldsymbol{X}$ on $\boldsymbol{y}$ in the equilibrium for the system. The results are presented in Table 2. Columns (1) to (4) of Table 2 present the estimated coefficients, direct, indirect and total impacts of the S2SLS estimation of the spatial lag model, respectively; while Columns (5) to (8) provide the GS2SLS results of the SAC model, assuming a general process for the residuals. Estimated coefficients and total impacts presented here are just informative, but for the remainder of the paper, only the post-estimation summary measures of the so-called direct and indirect impacts of the SAC model (Columns (6) and (7)) will be discussed.

The most important finding from Table 2 is that the estimated interaction coefficient ($\boldsymbol{\rho}$) is positive and statistically significant at well over a 99 percent confidence level, and occurs with a magnitude of approximately 0.47 regardless of which estimation method or model specification is considered. This finding provides evidence of spatial interaction in the land use conversion decisions between neighboring municipalities. A local government's decision on the additional amount of land assigned for new development is positively influenced by the decisions of neighboring 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, so that they can attract new residents to their jurisdictions, hence increasing tax bases and local revenues.

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. Several interesting findings arise from the results, and they will be briefly discussed. First, the *vacant land* in each municipality has a clearly negative and significant impact on the amount of additional land assigned for new development.

Second, the effect of demand increases and employment shocks are proxied here with a set of local socio-economic variables. The results show that the *income* variable plays an important role in explaining local land use conversion. In particular, richer jurisdictions tend to exhibit decreasing land use conversion rates, as the coefficient for the direct impact is negative and statistically significant. This result is in line with the literature, as richer communities tend to avoid additional urban development in their neighborhoods. The positive and statistically significant indirect impact reflects the presence of spillover effects of income in neighboring jurisdictions.

Third, we consider the amenity factors deemed important for location decisions. As expected, there is a more intense land use conversion activity in those locations with better road accessibility, which will ultimately translate into higher urban development, as shown by the positive coeficient of the *road density* variable. In the same vein, the higher the number of *vehicles per household*, the higher the land converted from rural to urban uses. This result is in line with a growing body of the literature that has focused on the influence of transportation system improvements and availability of roads on the demand for urban growth (Baum-Snow, 2007; García-López, 2012). In addition, the amount of *open land* is also crucial in explaining land use conversion rates and, as expected, this variable exhibits a positive effect on land use conversion rates (with both a direct and an indirect impact).

Fourth, we test the hypothesis that natural barriers can either promote or constrain development. As expected, there is less land use conversion whenever mountains are present (measured here with the *elevation range*) as they make development more costly, hence limiting urban expansion. The expected negative effect of this variable provides compelling evidence that physical geography influences urban development. 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. On the other hand, the presence of aquifers (*inland waters*) is positively correlated to land use conversion, as it lowers the cost of obtaining household water, hence facilitating urban development; whereas land is undevelopable whenever *water bodies* (such as wetlands and oceans) are present and, therefore, urban development is contained and land use conversion useless (Burchfield et al, 2006). The significance of the indirect impact for these variables is due to the fact that the dimensión of these phenomena exceed the administrative boundaries of the municipalities, hence generating spillover effects across jurisdictions.

Fifth, the results show that the land use conversion is higher in the *suburbs* of the metropolitan areas. These locations are, in fact, the ones experiences higher demand pressures for additional (sub)urban growth.

Last, but not least, the political factors turn out to be determinant in the process of land use conversion. 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 cities controlled by right-wing parties parties allow more land to be developed than similar cities controlled by the left, thus promoting more urban development (Kahn, 2011; Solé-Ollé and Viladecans, 2013).

[insert Table 2 around here]

6. Concluding remarks

A long line of research in economics analyzes the factors that shape local zoning and land-use regulations, as these regulations 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. Understanding the mechanisms through which local governments' decisions and their interactions with nearby and upper-tier governments is key for two reasons. First, to increase the knowledge about the performance of local governments in the economy. And second, to shed light on the role that the institutional setting in Spain plays in land use conversion, urban development patterns and, thus, the shape of cities.

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 financing 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 simple theoretical model has been derived and then tested empirically with data on more than 2,000 Spanish municipalities for the period 2003-2011. The empirical evidence supports the main hypothesis derived from the theoretical model, as we find a positive and significant effect of the interaction coefficient. That is, local governments' land-use decisions are positively influenced by the decisions made in nearby jurisdictions. In our setting, a local government does not care directly about the amount of converted land levels of other local governments but about the amount of residents that can be attracted to its jurisdiction (*resource-flow model*). The distribution of residents among jurisdictions is affected by the converted land choices of all local governments. Therefore, each local government is indirectly affected by other neighboring local governments' decisions. In our setting, reaction functions arise because the mobile tax base reacts to the regulatory measures that modify land uses in the municipality. This procedure results is an inneficient excess of land devoted to urban development.

Overall, the 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 a non-optimal allocation of resources. A system for financing municipal budgets that heavily relies on volatile revenues linked to the real estate cycle, fueled by laws on land use that create the undesired incentives for excessive land use conversion, 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 inefficient urban development. This revised local finance system should not be linked to the real estate cycle and, at the same time, it should also take into account the benefits lost by local governments when committed to sustainable urban development, while creating the proper incentives for promoting environmental and health benefits to local communities.

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Table 2: Estimation results

	Spatial Lag 2SLS					SAC GS2SLS (general form for disturbance process)				
	(1)		(2)	(3)	(4)	(5)		(6)	(7)	(8)
Spatial dependence:	Estimated parameters		Direct impacts	Indirect impacts	Total impacts	Estimated parameters		Direct impacts	Indirect impacts	Total impacts
Rho	0.4724***	(0.093)				0.4724***	(0.091)			
Lambda	--					--				
Control variables:										
Vacant land (%)	-0.1673**	(0.083)	-0.1791	-0.1381	-0.3173	-0.1673	(0.161)	-0.1791**	-0.1381	-0.3173*
Income (logs)	-1.9222***	(0.430)	-2.0572***	-1.5866**	-3.6439***	-1.9222***	(0.434)	-2.0572***	-1.5866***	-3.6439***
Homeownership rate (%)	-0.0075	(0.006)	-0.0080	-0.0062	-0.0143	-0.0075	(0.007)	-0.0080	-0.0062	-0.0143
Employment rate (%)	0.0158	(0.011)	0.0169	0.0130	0.0300	0.0158*	(0.009)	0.0169	0.0130	0.0300
Population (logs)	0.0463	(0.053)	0.0495	0.0382	0.0878	0.0463	(0.045)	0.0495	0.0382	0.0878
% Aged 25-45	-0.0178	(0.019)	-0.0190	-0.0147	-0.0338	-0.0178	(0.019)	-0.0190	-0.0147	-0.0338
Open Land (%)	0.0014***	(0.000)	0.0015***	0.0011*	0.0027***	0.0014***	(0.000)	0.0015***	0.0011**	0.0027***
Forest (%)	0.0002	(0.002)	0.0002	0.0001	0.0004	0.0002	(0.002)	0.0002	0.0001	0.0004
Distance to the coast (km)	-0.0643	(0.150)	-0.0689	-0.0531	-0.1220	-0.0643	(0.194)	-0.0689	-0.0531	-0.1220
Road density (km/pop)	7.1352*	(3.923)	7.6363**	5.8895	13.5259*	7.1352**	(3.299)	7.6363*	5.8895	13.5259*
Distance to road (km)	-0.0037	(0.007)	-0.0040	-0.0031	-0.0071	-0.0037	(0.006)	-0.0040	-0.0031	-0.0071
Vehicles per household	1.2864***	(0.382)	1.3768***	1.0619*	2.4387**	1.2864***	(0.477)	1.3768***	1.0619**	2.4387***
Blight (%)	0.0111	(0.007)	0.0118	0.0091	0.0210	0.0111	(0.009)	0.0118	0.0091	0.0210
Terrain ruggedness index (km)	6.0190	(7.797)	6.4417	4.9681	11.4099	6.0190	(8.294)	6.4417	4.9681	11.4099
Elevation range (km)	-0.4258**	(0.195)	-0.4557**	-0.3515	-0.8073*	-0.4258**	(0.184)	-0.4557**	-0.3515*	-0.8073**
Inland water (%)	0.0625*	(0.035)	0.0668**	0.0515*	0.1185**	0.0625**	(0.024)	0.0668*	0.0515	0.1185*
Water bodies (%)	-0.0571**	(0.026)	-0.0611***	-0.0471*	-0.1082***	-0.0571***	(0.134)	-0.0611**	-0.0471*	-0.1082**
dSuburb	0.3338***	(0.105)	0.3572***	0.2755*	0.6328***	0.3338***	(0.102)	0.3572***	0.2755**	0.6328***
dLeft	-0.4136***	(0.103)	-0.4426***	-0.3414*	-0.7841***	-0.4136***	(0.103)	-0.4426***	-0.3414**	-0.7841***
dMajority	0.1096	(0.101)	0.1173	0.0905	0.2079	0.1096	(0.094)	0.1173	0.0905	0.2079
Constant	17.1120***	(3.875)				17.1120***	(3.868)			

The dependent variables is the additional amount of land assigned for new development in each municipality between 2003 and 2011 (two terms-of-office). Column (1) reports the spatial lag results (S2SLS with heteroskedastic innovations of unknown form). Column (5) reports the S2SLS results with Spatial HAC standard errors for the specification with spatial lag and spatial error dependence (assuming a very general form for the disturbance process). Columns (2) and (6) report the corresponding direct impacts; Columns (3) and (7) report the corresponding indirect impacts; Columns (4) and (8) report the corresponding total impacts. Numbers in brackets report heteroskedastic-consistent standard errors (HAC standard errors in Columns (1) and (5)). ***, ** and * indicate significance at the 1 percent, 5 percent and 10 percent level, respectively.