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Does zoning follow highways?☆

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ABSTRACT

We study whether local zoning policies are modified in response to demand shocks generated by new highways. We focus on the case of Spain during the period 1995–2007. The empirical strategy compares the variation in the amount of developable land before–after the construction of the highway in treated municipalities and in control municipalities with similar pre-treatment traits. Our results show that, following the construction of a highway, municipalities converted a huge amount of land from rural to urban uses. The amount of new land declared to be developable was larger in places with low construction costs or high demand, suggesting that zoning follows market forces. However, the impact of the highway was lower in places where residents were less favorable to development or where developers had more influence over zoning policies. Local political factors thus impede the full adaptation of zoning to economic changes.

1. Introduction

Land use regulation is a ubiquitous feature of land markets. Urban growth boundaries place limits on the spatial expansion of cities (Hannah et al., 1993), and zoning ordinances designate permitted uses of land and regulate many other aspects of development (Glickfeld and Levine, 1992; Cheshire and Sheppard, 2004). The effect of these regulations on welfare is difficult to determine, although there is little evidence of a net positive effect (McMillen and McDonald, 1993; Turner et al., 2014). Some authors even suggest that 'the regulations tend to coincide with, or anticipate, the market solution rather than modify it' (Wallace, 1988, p.307). If we accept that 'zoning follows the market', regulations would be unnecessary as governments would provide the same land use patterns as those afforded by the unconstrained market. Such a situation might come about as private agreements tend to mimic centralized decisions dealing with externalities (Fischel, 1985). It might also be the case that local governments cater in the main to development-related interests as opposed to those of homeowners (Molotch, 1976; Solé-Ollé and Viladecans-Marsal, 2012; Hilber and Robert-Nicoud, 2013). So, eventually, when obliged to modify their planning documents, they tend to take decisions that allow proposed developments to go ahead. From this perspective, not only are land use regulations meaningless, they are also likely to have a detrimental effect. This is the case if a government's response to market forces is delayed, thereby reducing the supply elasticity of residential land and contributing to housing price increases (Mayer and Somerville, 2000; Glaeser and Ward, 2006).

In this paper, we examine whether zoning policies do indeed follow market forces by studying whether local governments respond to demand shocks by allowing more land to be developed. More specifically, we study the decisions of Spanish local governments to convert land from rural to urban uses during the period 1995–2007. We focus on a specific kind of demand shock—the construction of a new highway segment—and study its impact on the growth in the amount of land designated for development, taking into account the timing of any effects. We then analyze whether these effects are heterogeneous, considering (i) the strength of the demand shock, (ii) geographical constraints, (iii) the amount of vacant land, (iv) the degree of local support/opposition to development, and (v) the degree of influence developers have over zoning policies.

The paper makes two main contributions to the literature. First, to the best of our knowledge, no one has previously analyzed the way in which local governments make zoning decisions following a demand shock. Some authors have studied whether the *ex post* land use pattern is consistent with that which would have been generated by market

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forces (Wallace, 1988; McMillen and McDonald, 1993; Turner et al., 2014), but none specifically analyze how local governments modify their decisions in response to changes in market conditions over time. The cross-sectional nature of most databases employed in the literature examining the determinants of zoning (Bates and Santerre, 1994, 2001; Evenson and Wheaton, 2003; Sáiz, 2010) does not permit a dynamic analysis like the one we perform here. In this paper, we are able to draw relevant conclusions as to whether (and the conditions under which) zoning decisions anticipate market forces and about the time required for this to happen. Second, although there is a growing body of literature documenting the effects of highways on city growth and urban sprawl (Baum-Snow, 2007; Duranton and Turner, 2012; Baum-Snow et al., 2014; Garcia-López, 2012; Garcia-López et al., 2015), these studies do not consider the possibility that the impact of highways on the local economy might be mediated by the way in which local zoning policies are drawn up. It is perhaps tempting to interpret the results of this literature as indicating that zoning does not interfere greatly with market forces, since on average such regulations are unable to stop highways from having a considerable impact on the local economy. Here, however, we argue that behind this average effect of highways, there might lie considerable heterogeneity and that the effect on a specific community may well depend on local preferences and political traits. Even if zoning completely responds to highways in the long run, it might be that this response comes with a substantial delay, thus slowing the path of real development and fuelling increases in real estate prices. In this paper, we explore this issue by comparing the time path of zoning modifications and that of real development outcomes.

There are various reasons why Spanish local governments provide an excellent testing ground for these ideas. First, they are periodically required to pass comprehensive zoning documents, specifying which land plots can be developed and which have to remain undeveloped. We have been fortunate in being able to access a unique database containing information on the amount of land designated for development by all of Spain's municipalities over a long time period. Second, the fact that Spanish local governments enjoy almost complete freedom in areas related to zoning policies, coupled with the fact that highway provision is the exclusive concern of higher layers of government, makes Spain the ideal institutional setting for our analysis. Finally, the period analyzed (1995–2007) witnessed a demand shock of an extraordinary magnitude, creating extremely high expectations of construction growth, which forced local governments to take decisions regarding whether or not to allow this growth.

Our results show that, following the construction of a new highway segment, the municipalities converted a huge amount of land from rural to urban uses. We can confirm that the amount of land converted was greater in places with higher demand and fewer geographic constraints, which suggests that zoning does indeed follow market forces. However, land conversion was also greater in places where local residents were more favorable to development and/or in places where development interests had more influence over the local planning process, which suggests that local preferences and political factors impede the full adaptation of zoning to economic changes. Furthermore, we show that these effects are also present when we analyze the effects of highways on the amount of land actually developed and on the number of housing units built.

The paper is organized as follows. In Section 2, we describe the system of zoning in Spain and the recent expansion of the Spanish highway network. Section 3 describes the methodology used in the analysis, and Section 4 presents the results. Finally, Section 5 concludes.

2. Institutions and data

2.1. Zoning regulations

Responsibility for specifying and implementing zoning regulations in Spain lies with the more than 8,000 municipalities (though most are small, with 60% having less than 1,000 inhabitants). And even though Spain's regional governments can reject local zoning regulations on the grounds that they interfere with their policies, it is generally held that during the last economic boom, the regional governments were largely ineffective in detaining local land development. Moreover, regional governments are powerless to force local governments to accept either the quantity or the type of development they want.

Zoning regulations in Spain are controlled by a highly detailed, rigid system (Riera et al., 1991), an essential characteristic given that landowners cannot develop their land without the prior consent of the local administration. Municipalities draw up a 'General Plan', which provides a three-way land classification: *developed land*, *developable land* (areas where future development is allowed), and *non-developable land* (areas where development is prohibited, at least until a new plan is approved). The 'General Plan' has to be updated from time to time in order to adapt land use regulations to economic and demographic changes. The process of amending the 'General Plan' is complex and can take at least a full term of office to complete. The plan, drawn up by the government team, has to be approved by a majority of the city council. Many transparency and participation requirements have to be fulfilled (public display or hearings, appeals), involving both opposition parties and the citizenry. Fortunately, for our purposes, we enjoyed access to a new dataset that provides information on land use categories at the municipal level (Spanish Property Assessment Agency, Ministry of Economics) and which is derived from the assessment process that this agency undertakes on all properties in the country. From this database, we obtain information on the amount of *developable land* and of *developed land*, as well as a proxy of residential development (the number of *housing units*). Our empirical analysis focuses on the evolution of the amount of *developable land* from 1995 to 2007, which increased considerably during this period (thus, between 1995 and 1999, there was a marked rise equivalent to 28.6% of the build-out area in 1995; this figure jumped to 73.3% by 2003 and to 113.5% by 2007).

2.2. Highway construction

Over the last three decades, Spain has undertaken a highly ambitious expansion of its highway network; thus, between 1980 and 2011, more than 10,000 km of new highways were built. However, the period from 2003 to 2007 saw the greatest number of kilometers of new highways built per year (with an overall total of 2,446 km). Both the central and the regional governments have responsibilities over road construction, but during the period of analysis, most highways have been built by the central government (80% of segments and 90% of km). Thus, in effect, the paper analyzes the reaction of the zoning enacted by local governments to the highways constructed by higher tiers of government.

Using GIS software, we created digital vector maps (highway and other main road segments) and associated them with the municipalities. The network is characterized, first and foremost, by its highly radial pattern whereby many highways emanate from Madrid, the geographical center of Spain; and, second, while construction work up to 2000 strengthened this radial network, subsequently, a mesh-like structure has been created with direct connections being built between Spain's medium-sized cities but without crossing Madrid.[1]

3. Empirical analysis

3.1. Identification strategy

One of the most challenging problems researchers face when evaluating the effects of road construction on economic outcomes is that places that gain access to a new road probably differ from places that

[1] Good examples are segments of the A-66 highway running North-South parallel to the Portuguese border (the 'Autovía de la Plata') and the A-23 highway in the North-East of Spain, linking Zaragoza and Teruel.

do not obtain such access. Many recent papers have dealt with this issue by seeking an exogenous source of variation in road construction. The instruments they employ are usually constructed with information on planned or historical routes (Baum-Snow, 2007; Duranton and Turner, 2012; Baum-Snow et al., 2014). This approach has also been adopted for the Spanish case by Garcia-López (2012) and Garcia-López et al. (2015). Unfortunately, we are unable to use these instruments as the highway segments we work with (those built between 2003 and 2007) do not adhere to the traditional radial network centered on Madrid. We are also unable to extend the period of analysis to include pre-2003 construction because the zoning regulation data are only available for this more recent period.

Instead, we use a before–after analysis and compare the evolution of the outcome of interest in treated and untreated municipalities. We are specifically concerned with economically small units (municipalities) lying on highway segments that form part of longer infrastructures linking medium-sized cities. This suggests that, provided the highway follows the most convenient route between its two end points, the unobserved characteristics of the municipalities lying on the link should be unrelated to the treatment. Clearly, in practice, there may well be several alternative routes for connecting two given cities, but one of these might be chosen because the municipalities lying on it share a common trait, for example, they are linked by an old road, the topography is favorable, or they wield greater political clout. To overcome this, we compare the amount of land converted over a period of time in our treated municipalities (those obtaining a new highway access) with the amount converted in other municipalities that present similar characteristics. To do so, we restrict our analysis to municipalities that previously had access to a main road, and within this set, we select a proper control group using 'propensity score matching'. In this way, we ensure that we are comparing municipalities with the same pre-treatment characteristics (including lagged land use values). Moreover, the availability of several cross-sections of data allows us test the validity of our research design by examining whether highway construction had an impact in the years prior to the treatment period.

3.2. Research design

3.2.1. Sample

Our initial sample includes 1,841 municipalities and reflects the availability of our data. The information on new highway segments covers the whole of Spain (with the exception of the Canary Islands), but the database on land use categories is unavailable in the regions of the Basque Country and Navarra and information is incomplete for some municipalities. Moreover, most of the other databases we use are limited to municipalities with more than 1,000 inhabitants. Thus, we include all Spanish municipalities with more than 5,000 inhabitants and approximately 50% of those with between 1,000 and 5,000. We believe the final sample to be representative of the population, at least for the municipalities with more than 1,000 residents.

3.2.2. Treated municipalities

We define our treated units as the municipalities in our sample that gained highway access during the period 2003–2007 but which had access to a main road in 2003. During the period of study, 291 municipalities gained access to a new highway. Of these, 14 did not have access to a main road prior to that period. This suggests that restricting the analysis to the sample with prior access to a main road might make sense. Of the remaining 277 municipalities (= 291 − 14), 129 have less than 1,000 residents, and 49 have between 1,000 and 5,000 residents, but we did not have access to all the required data for them. This leaves us with 99 municipalities (see Figure A.1 in the Online Appendix) that (i) gained highway access between 2003 and 2007, (ii) had access to a main road in 2003, and (iii) for which we have all the data.

3.2.3. Control municipalities

We define our control units as the municipalities that fulfill three conditions: (i) they did not gain highway access between 2003 and 2007, (ii) they had access to a main road in 2003 but not to a highway, and (iii) they did not belong to the same local labor market as any of the treated municipalities (we employ local labor markets based on commuting patterns). In our sample, 742 municipalities already had access to a highway in 2003 and so have to be discarded as controls. The remaining 986 municipalities (= 1,827 − 742 − 99) did not have highway access in 2007. Of these, 663 did have access to a main road in 2003, and 323 were located in a local labor market not containing any of our treated municipalities. These 323 municipalities, therefore, constitute our control group. The exclusion of municipalities not gaining direct access to the highway but belonging to the same local labor market as the treated units serves to ensure that the controls are not affected by the treatment, since this would bias the estimated effect of the highway on economic outcomes.

3.2.4. Matching

The set of control municipalities is further refined using 'propensity score matching', which ensures that treated and control units are balanced in terms of observables (Rubin and Thomas, 1996; Rubin, 2001). Here, we use this method to preprocess our sample; thus, restricting our estimation to the matched sample (Rosenbaum and Rubin, 1985). We then adhere to the recommendation of Ho et al. (2007) and estimate a parametric model with the data of our final matched sample. In order to improve our estimates, we control again for the covariates used in the construction of the propensity score (Abadie and Imbens, 2011).

We first estimate a logit, using as the dependent variable a dummy equal to one if the municipality gained access to a new highway during the period 2003–2007 (and zero otherwise), and as regressors, we use variables deemed to have an influence on both the location of the new highway segment and on the conversion of land from rural to urban uses. The variables used can be classified into the following groups: (i) demand variables (major urban area dummy, population in the municipality and in the urban area, population growth, unemployment rate), (ii) geographical constraints (ruggedness, availability of open land); (iii) political variables (co-partisanship between the mayor and the regional president, incumbent's ideology and electoral competition at the regional level); and (iv) land use at the beginning of the period (amount of vacant land). We then match each treated unit with a control using 'nearest neighbor matching with replacement'. In this way, in our final matched sample treated municipalities have the same traits as those of the controls. More details on the variables and on the validation of the 'propensity score matching' can be found in the Online Appendix.

3.2.5. Timing of treatment

As explained above, we know the period in which each of the highway segments was completed. However, reactions to the new highway might have started several years earlier if the local government used information about related events (inclusion of the project in a road plan, the initiation of the tendering process, onset of construction) to forecast when a new highway might be accessible in the future. Clearly, we have no information about these events for each of our segments. However, there is some anecdotal evidence showing that zoning modifications may indeed commence some years before the opening of a highway.[2]

[2] An article published in *El País* newspaper put it this way: "The construction of the highway is accelerating a massive process of land use conversion. (…) thirteen municipalities have already enacted planning modifications to allow for 550,000 homes and 25 golf courses" (12/03/2005). The article refers to highway segment AP-7 Cartagena-Vera: the project was first included in a national road plan in 2000, tendering was complete by the end of 2003, construction began in November 2004, and the highway opened in March 2007. Many planning modifications had already been enacted in the period 2003–2005, and some even before that (Martín García, 2010).

More specifically, reaction to a new highway should first be noted when the local government believes construction will go ahead, that is, once the tendering process is complete and construction is underway. At this juncture, the local government can reasonably expect the highway segment to be built and for it to be completed in around four years.[3]

This means that for projects completed between 2003 and 2007, it is reasonable to expect that it was the local incumbent during the previous term (i.e., 1999–2003) that started to consider the possibility of amending the master plan in order to convert land from rural to urban uses. Fig. 1 illustrates the timing of our treatment: the treatment period (labeled *after treatment*) covers the period 1999–2007, and is divided into two sub-periods, 1999–2003 when the project was presumably started, and 2003–2007 which is when we know that the project was completed. The period 1995–1999 is the period *before treatment*: the year 1995 is our initial period, used as the baseline for comparisons of the evolution of the outcome variables and to measure pre-treatment characteristics; the year 1999 is reserved to perform a validity test, since we do not expect the treatment to have any effect on the outcomes for 1999.

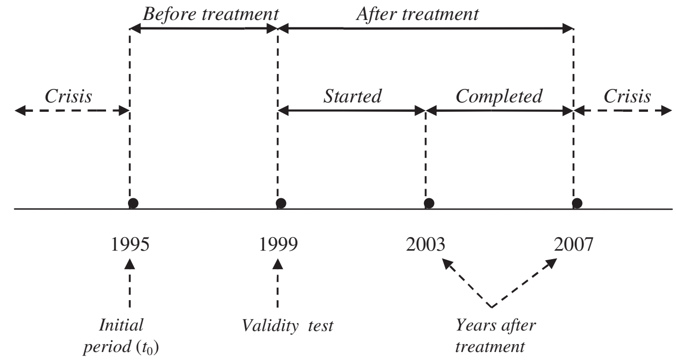


Fig. 1. Timing of the treatment.

3.3. Estimated equation

We estimate the effect of receiving the treatment during the period that extends from year t_0 (before treatment) to some year in the future t (after treatment) on the growth in the outcome variable between these two moments in time. The treatment variable is denoted by Δh_i and is a dummy equal to one if municipality i gained access to a new highway during the period, and zero otherwise. The estimation is performed with the sample containing a subset of the municipalities with prior access to a main road, selected using matching techniques.

Our main outcome variable is the increase in developable land relative to developed land at the beginning of the period ($\Delta d_{i,t\text{-}t0}$). We estimate the following equation:

$$\Delta d_{i,t-t0} = \alpha + \beta_1 * \Delta h_i + z'_{i,t0}\gamma + \varepsilon_{i,t} \tag{1}$$

where $\boldsymbol{z}_{i,t0}$ is a vector of municipal characteristics either time-invariant or measured before treatment, and $\varepsilon_{i,t}$ is an error term with the usual properties. The variables included in $\boldsymbol{z}_{i,t0}$ are the same as those used in the selection of the matched sample.

The before–after analysis allows us to eliminate any time-invariant factors that may have an influence on the decision to convert land from rural to urban uses and on the decision to build a highway in a given place. Clearly, there might be time-invariant omitted factors, which are simultaneously correlated with $\Delta d_{i,t\text{-}t0}$ and Δh_i. We deal with this problem by assuming unconfoundedness given lagged policy outcomes and other pre-treatment variables (Imbens and Wooldridge, 2009). So, we include in the $\boldsymbol{z}_{i,t0}$ a measure of the percentage of vacant land.

One way of assessing the validity of the unconfoundedness assumption is to estimate the causal effect of the treatment on a variable known to be unaffected by it, typically because its value is determined prior to the treatment itself (Imbens and Wooldridge, 2009). To implement the test, the vector of covariates has to be split in two groups, separating a pseudo-outcome from the other variables. Here, our pseudo-outcome is the increase in developable land from 1995 (the initial period) to 1999 (the year before the treatment period begins). When testing for the treatment effects on the increase in developable land during the period 1995–1999, we also control for pre-treatment covariates, including the amount of vacant land in 1995. Actually, this test can be implemented together with the estimation of the treatment effects for the period after the treatment. The estimated equation is as follows:

$$\Delta d_{i,t-t0} = \alpha + \beta_1 * \Delta h_i + \beta_2 * after_t * \Delta h_i + z'_{i,t0}\gamma + \delta_t + \varepsilon_{i,t} \tag{2}$$

Here, we pool three cross-sections of data, corresponding to the periods 1995–1999, 1995–2003, and 1995–2007. The dummy *after* is equal to one for those periods ending in a year in which we expect new highways to have an effect (2003 and 2007) and zero for the period 1995–1999, and δ_t are period fixed-effects. A test of whether β_1 is equal to zero allows us to assess the uncounfoundedness assumption: conditional on $z_{i,t0}$, the effect of Δh_i on $\Delta d_{i,1995-1999}$ should be zero. The parameter β_2 is the treatment effect in which we are interested. In fact, since the effect of the highway might change over time, it is convenient to allow for different effects in the two treatment sub-periods. This is the equation we estimate to obtain these period-specific effects:

$$\begin{aligned}\Delta d_{i,t-t0} = {} & \alpha + \beta_1 * \Delta h_i \\ & + \beta_2 * started_t * \Delta h_i + \beta_3 * completed_t * \Delta h_i \\ & + z'_{i,t0}\gamma + \delta_t + \varepsilon_{i,t}\end{aligned} \tag{3}$$

where *started* is a dummy equal to one for the period ending in 2003 and *completed* is a dummy equal to one for the period ending in 2007. Eqs. (2) and (3) are estimated by OLS with standard errors clustered at the municipality level.

Finally, in order to allow for heterogeneous effects, Eq. (2) is re-estimated allowing the treatment to be different in the two different regimes:

$$\begin{aligned}\Delta d_{i,t-t0} = {} & \alpha + \beta_1 * \Delta h_i \\ & + \beta_{21} * d(x_i < \overline{x}) * after_t * \Delta h_i + \beta_{22} * d(x_i \geq \overline{x}) * after_t * \Delta h_i \\ & + z'_{i,t0}\gamma + \delta_t + \varepsilon_{i,t}\end{aligned} \tag{4}$$

where $d(x_i < \overline{x})$ and $d(x_i \geq \overline{x})$ are two dummies equal to one if the value of a given variable is lower/higher than a given threshold (usually the median of the distribution).[4] The variable x is also a pre-determined variable but may or may not be one of the variables included in the vector $\boldsymbol{z}_{i,t0}$. Based on the insights of a simple model (see the Online appendix), the interacted variables measure (i) the strength of the demand shock, (ii) geographical impediments to building, (iii) the amount of vacant land at the outset, (iv) the preferences of locals for/against development, and (v) the relative influence wielded by developers.

[3] This account matches well with the example in footnote 2. However, it seems to be generally applicable, as confirmed by an internet search of public information (Memoranda of the Spanish Ministry of Public Works or press information about tenders) regarding the evolution of several highway projects during the period analyzed (segments of highways A-66, 'Autovía de La Plata', A-23 Zaragoza-Teruel, and AP-7 Cartagena-Vera).

[4] Not all the potential covariates were eventually included in the logit used to estimate the 'propensity score'. Where one of the x variables was not included in the $\boldsymbol{z}_{i,t0}$ vector, we added the dummy as a control in the estimation. Similarly, a more flexible estimation would involve allowing the β_1 coefficients to vary between the two regimes.

The proxy for the strength of the demand shock is *Urban area population*.[5] The variables accounting for the geographical impediments to building are terrain *Ruggedness* and availability of *Open space*. The variables considered as being related to the residents' preferences are *%Homeowners* and *%Commuters*. Both groups are assumed to be opposed to development: homeowners because they believe development will depress the value of their property (Fischel, 2001; Dehring et al., 2008; Hilber and Robert-Nicoud, 2013) and commuters because they work outside the community and so do not benefit from improved job prospects in town. Finally, we also estimate separate treatment effects for *Right vs. Left-wing* governments and for *Majority vs. Non-majority* governments. The ideology of the government might either account for residents' preferences (residents more opposed to growth vote for the left, since the left tends to restrain development; Solé-Ollé and Viladecans-Marsal, 2013a) or be a proxy for the congruence between the preferences of land developers and politicians (if developers and landowners have more connections with right-wing parties; see Solé-Ollé and Viladecans-Marsal, 2013b). Mayors backed by council majorities might feel electorally safer and may thus be more willing to disregard the interests of voters and favor those of developers (Solé-Ollé and Viladecans-Marsal, 2012).

4. Results

4.1. Main results

Table 1 presents the results obtained when estimating Eqs. (2) and (3). In Panel (a), we estimate the *overall effect of new highways* (Eq. 2) throughout the whole treatment period (identified via the *after* dummy). In Panel (b), we provide more detailed information regarding the *effect of new highways over time* (*started* and *completed* dummies, which refer to the period 1999–2003 and 2003–2007). Column (i) reports the results without covariates (with just the year fixed effects) and column (ii) adds the full set of controls.

The average effects of highway construction throughout the whole treatment period are positive and statistically significant. The results in column (ii) indicate that a municipality gaining access to a new highway experienced an increase in the amount of developable land of around 89% of the amount of developed land in 1995. The results in Table 1 Panel (b) suggest that most of the effects occurred during the first municipal term of office (1999–2003). The estimated treatment effect by 2003 is around 70%, rising to around 100% by 2007. However, a simple test of equality of coefficients is unable to reject that these two numbers are equal.

Fig. 2 shows the evolution of the amount of developable land, which is the summation of the amount of vacant land at the outset (as of 1995) and the (estimated) increase in developable land. The coefficients used to draw this graph are taken from column (i). It is quite clear that there is a differential trend and that this trend does not differ greatly in the two treatment periods. The graph also emphasizes that the level in 2007 is higher than that reached in 2003.

A possible concern regarding these results is that they might simply be picking up the fact that places benefiting from highway construction are just different from other locations. Yet, note that the results in Table 1 also provide the information needed to test the 'uncounfoundedness' assumption. The coefficient estimated for Δh_i is not statistically different from zero, suggesting that localities that gained access to a highway and those that did not grew no differently during the period 1995–1999. Note also that treated and control municipalities are identical with regard to their respective amounts of vacant land in 1995 (see the equality of means tests presented in the Online Appendix).

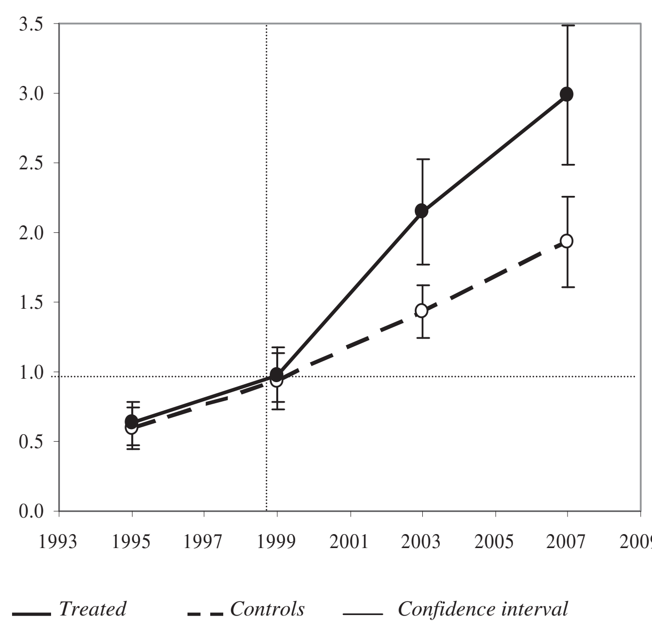
Table 1
Effects of new highways on zoning policies.

	Dependent variable: Increase in			
	Developable land ($\Delta d_{i,\ t\text{-}t0}$)		*Developed land* ($\Delta b_{i,\ t\text{-}t0}$)	*Housing units* ($\Delta u_{i,\ t\text{-}t0}$)
	(i)	(ii)	(iii)	(iv)
(a) Overall effect of new highways				
Δh_i	−0.049	0.046	−0.015	−0.030
	(0.289)	(0.279)	(0.245)	(0.201)
Δh_i*$after_t$	0.669	0.886	0.523	0.090
	(0.268)**	(0.293)***	(0.308)*	(0.044)**
Adjusted R^2	0.095	0.214	0.219	0.258
(b) Effect of new highways over time				
Δh_i* $started_t$	0.715	0.717	0.376	0.051
	(0.377)*	(0.338)**	(0.295)	(0.040)
Δh_i*$completed_t$	1.054	1.056	0.612	0.130
	(0.386)***	(0.322)***	(0.241)**	(0.062)**
$Started_t = completed_t$	0.349	0.339	0.236	0.079
(F-test p-value)	(0.536)	(0.328)	(0.198)*	(0.049)*
Adjusted R^2	0.096	0.214	0.218	0.259
Time fixed effects	YES	YES	YES	YES
Control variables	NO	YES	YES	YES
Obs.	462 = 154x3	462	462	

Notes: (1) $\Delta d_{i,t\text{-}t0}$ = outcome variable (increase in the amount of developable land, as a proportion of initial amount of build-out land). (2) Municipalities included in control group are selected via matching from those with prior access to a main road. (3) Δh_i = treated units (municipalities gaining access to a new highway during the period). (4) $after_t$: Dummy for the treatment periods. (5) Estimation method weighted least squares. (6) Control variables: used in the estimation of the 'propensity score' (see Online Appendix). (7) In parentheses, standard errors; ***, **, and * indicate that the coefficient is statistically significant at the 1%, 5% and 10% levels; standard errors clustered at the municipality level.

4.2. Interaction effects

Table 2 shows the results for Eq. (4) when we allow the effect to differ between groups of municipalities. The results in Table 2 confirm



Notes: (1) Effects in municipalities with a new highway access. Coefficients estimated by *Diff-in-diff + Matching*.

Fig. 2. Evolution of developable land ($d_{i,t}$) in treated and control municipalities.

[5] Construction activity during the period of analysis was most intense in urban areas and on the coast. Coastal status, however, did not have any explanatory power in our logit model.

Table 2
Heterogeneous effects of new highways on zoning policies.

Dep. var.: increase in Developable land ($\Delta d_{i,t\text{-}t0}$).				
	(a) *Demand and supply*			
	Urban area population	*Ruggedness*	*% Vacant land*	*% Open land*
	(i)	(ii)	(iii)	(iv)
Δh_i*$after_t$ * (Dummy = *Low*)	0.231	1.237	1.014	0.306
	(0.320)	(0.506)***	(0.397)**	(0.415)
Δh_i*$after_t$ * (Dummy = *High*)	1.071	0.529	0.280	0.954
	(0.406)**	(0.289)*	(0.262)	(0.456)**
High – Low	0.840	−0.707	−0.915	0.647
(*F-test p-value*)	(0.383)**	(0.506)**	(0.557)*	(0.576)
Adjusted R^2	0.325	0.342	0.295	0.305
	(b) *Preferences for/against development*			
	% Homeowners	*% Commuters*	*Right-wing mayor*	*Majority Government*
	(v)	(vi)	(vii)	(viii)
Δh_i*$after_t$ * (Dummy = *Low*)	1.032	1.160	0.503	0.341
	(0.504)**	(0.477)**	(0.262)*	(0.167)*
Δh_i*$after_t$ * (Dummy = *High*)	0.653	0.361	1.215	1.302
	(0.303)**	(0.174)*	(0.478)***	(0.439)***
High – Low	−0.377	−0.865	0.711	0.965
(*F-test p-value*)	(0.574)	(0.447)*	(0.387)*	(0.373)***
Adjusted R^2	0.325	0.334	0.341	0.345

Notes: (1) Control group = *Matching*; all estimations include the same control variables as in Table 1. (2) Overall effect of new highways; we only report the coefficient of the interaction between Δh_i* $after_t$ and the dummies defining each regime. (3) Low/High: in columns (i) to (vi), dummy equal to one if the interaction variable is higher than the median; in columns (vii) and (viii), High is a dummy equal to one if there is a *Right-wing mayor* and a *Majority government*, respectively, and equal to zero if there is a *Left-wing mayor* or a *Coalition/ Minority government* otherwise.

most of the model's predictions. Panel (a) reports the results when the sample was split according to demand and supply variables, and Panel (b) reports the results when it was split in relation to preferences for or against development. In each column, we report the coefficient estimated for each of the regimes, with *High* and *Low* in most cases indicating whether the variable is above/below the sample median. However, when the variable used to split the sample is a dummy, *High* and *Low* indicate whether the dummy is equal to one or zero, respectively. The results show that: 1) the effect of a highway on land conversion is restricted mainly to the sample of municipalities located in the most populated areas and the difference between the two regimes is statistically significant; 2) the effects of a new highway are restricted to municipalities with a substantial amount of open land and whose topography is favorable; and 3) the effect of the highway on land conversion is statistically zero in places with a high amount of vacant land at the outset. These results suggest that, as expected, the effect of the construction of a new highway on zoning policies is restricted to places with high demand and good topography, and where the supply of developable land was restricted before the demand shock.

In the first two columns of Panel (b), we show how the effect of a new highway is also greater in places with a low proportion of homeowners and commuters. This impact is much more apparent in the case of commuters: in places with few commuters, the treatment effect is around 110% of the initial city size, while in places with a high proportion of commuters the effect is around 36%. The difference between places with a low and a high percentage of homeowners is smaller and not significant. Finally, in the last two columns of Panel (b), we show the estimated coefficients for right-wing vs. left-wing governments and for majority vs. other types of government. The results are striking in both cases. For example, the effect of a new highway on land conversion is much greater if the municipality is run by a right-wing mayor (120% vs. 50%), suggesting, therefore, that preferences of the local community matter. Zoning policies will follow highway construction to a lesser extent in places where the residents disapprove of development, in places where the mayor belongs to a party with an ideology that does not favor development or where the mayor is more constrained by electoral considerations.

Admittedly, however, these heterogeneous results need to be treated with extreme caution. Even if we had identified a causal effect in each of the subsamples, it would be difficult to attribute a causal difference in the treatment effect solely to the variable used in splitting the sample. Any of these variables might be correlated with other factors that have not been taken into account, and some of these factors have also been used for splitting the sample. To dissipate some of these doubts, we might stress that the correlations between all the variables used to split the sample are quite low, most being less than 0.10. In order to check whether this might be a problem for our results, we re-estimated each of the interaction regressions adding as extra interactions those between Δh_i*$after_i$ and the other interacted variables that presented the strongest correlation with the one under analysis. In all cases, the results regarding the interaction effect for the original variable did not change greatly.[6] This suggests that the results shown in Table 2 are substantive and not driven by the omission of other variables that are also interacting with the treatment.

4.3. Development outcomes

The response of Spanish municipalities to the building of a new highway segment, with the conversion of vast tracts of land from rural to urban uses, seems remarkable both in terms of quantity and speed. However, it is important to consider the effects on real outcomes by analyzing the actual amount of developed land. In particular, we focus on residential land uses by studying the number of housing units built. These considerations are undertaken in Table 1. Panel (a) presents the treatment effect over the whole *after* period and Panel (b) differentiates between subperiods. Column (iii) presents results for the increase in *Developed land* and column (iv) for the increase in the number of *Housing units*.

The results show that gaining access to a new highway also has an effect on the two specific outcomes considered. The average treatment effect is 52% in the case of developed land (vs. 89% in that of developable

[6] These results are available upon request. We also add to the equation interactions between the x's and Δh_i and also with the year fixed effects. The results were also qualitatively unchanged.

land). This divergence can probably be attributed to time lags in the development process. Although a number of development projects had already been started in the first period, others had to wait until the second term to be initiated and then several years were needed before these projects were completed. Panel (b) column (iii) of Table 1 confirms this intuition. In this case, the coefficient for the second period is much higher than that for the first period. This impression is confirmed when we specifically consider the growth in the number of housing units (column (iv)). Here the point estimate for the first period is statistically insignificant and nearly zero. The effect in the second period is much higher; however, note that this effect is much lower than that for the amount of developable land. This might be due to the fact that the type of development experienced in Spain during these years was extremely land intensive. Vast tracts of land were allocated to commercial and industrial uses and employed for the construction of parking lots and the housing of infrastructure. Unfortunately, the data currently available do not allow us to investigate these possibilities in any further detail.

4.4. Geographical scale

As the spatial area of the municipality is small, it would be reasonable to expect that a new highway would also have an impact on neighboring municipalities. Thus, we also examined the effects of the highway on municipalities belonging to the same local labor market as that of the municipality gaining direct access to the highway. The results can be found in the Online Appendix. The main conclusion is that the effect of the new highway extends to the rest of the local labor market, although this effect diminishes with distance from the highway. All in all, the construction of a new highway segment has a huge impact on the zoning policies enacted by nearby municipalities.

5. Conclusion

In this paper, we have found that the increase in the amount of land designated for development in Spain during the period 1999–2007 was twice as high in the municipalities gaining access to a new highway than it was in other municipalities. The results also show that most of this effect occurred during the early years coinciding with highway construction. This seems to suggest that municipalities are able to anticipate the effects of a highway thus ensuring that there will be sufficient land to start the projected developments at a later date. The impact of the highways also extended to such outcomes as the amount of land actually developed and the number of housing units. Overall, these results suggest that, while zoning policies appear to adapt to market forces quite rapidly, the time required to amend planning documents and implement the changes may contribute to delays in the completion of development projects. Our results are also highly heterogeneous. The impact is much lower in less urbanized areas and in places with a shortage of open spaces and with a very rugged topography. However, we offer some novel results that are often overlooked: for example, we find that places with a high proportion of homeowners and commuters tend to convert less land from rural to urban uses following the construction of a highway. On the other hand, municipalities with a right-wing mayor and with a majority government increase the land designated for development much more than is the case of other municipalities gaining access to a new highway.

Overall, our study depicts a fairly mixed scene. On the one hand, market forces had an enormous influence over the use of land, this despite the fact that Spain's land use regulations are strongly interventionist. The huge increase in the amount of land designated for development during the analyzed period, especially in places gaining access to a highway, is clear evidence that these regulations did not represent a complete impediment to development at the aggregate level. However, the need to adapt these regulations to the new conditions may have led to some delays in the development process. This might have occurred in places where residents and/or political representatives were openly opposed to growth and/or the political process was less permeable to the pressures of development lobbies. Both the delays and the prohibitions on new development might have impacted on the evolution of housing prices in Spain. However, this claim is very difficult to verify due to the lack of data. Yet, we might conclude that the highway construction boom experienced in Spain during recent decades could also have contributed to fuel the boom in housing prices. Finally, regarding the external validity of our results, we would expect them to be applicable in places where (1) zoning policies are a local responsibility and highway construction is the competence of a higher tier of government, and (2) politicians have some discretion whether to cater to the demands of resident voters or to those of the developers. These two traits are by no means specific to Spain and typify many areas in the US.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.regsciurbeco.2015.05.008.

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