The Impact of Zoning Ordinances on the Housing Market: Evidence for a Developing Country

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RESUMO:

Com a recente urbanização e aumento da densidade demográfica em torno das grandes cidades brasileiras, o mercado imobiliário do país sofreu uma grande valorização. Além de fatores relacionados à demanda, mecanismos com potencial para limitar a oferta de casas também podem ter afetado o aumento de preços nesse mercado. O objetivo do presente trabalho é investigar o impacto das ordens de zoneamento (restrições de uso do solo) sobre a média do preço de alugueis e sobre o crescimento do estoque de casas. Através de uma análise entre cidades e utilizando algoritmos de matching, observou-se que o zoneamento gera um incremento que varia de 5,4% a 6,3% no preço médio de aluguéis, mas não afeta o crescimento de casas. Além disso, conduzimos análises de sensibilidade que sugerem que esse resultado não é simplesmente guiado por confounders não observáveis. Nossa evidência sugere que mesmo sendo uma política bem intencionada, o zoneamento tende a gerar custos sociais que precisam ser considerados.

Palavras-chaves: Restrições de Uso do Solo, Zoneamento Urbano, Desenvolvimento Urbano, Brasil.

ABSTRACT:

Due to recent urbanization and the increased population density around major Brazilian cities, the real estate market in the country suffered a great appreciation. In addition to demand-related factors, mechanisms with potential to limit housing supply may have also affected the price increase in that market. The objective of this study is to investigate the impact of zoning orders (land use regulations) on the average rent prices and the real estate market growth in Brazil. Through an intercity analysis and using matching methods, it was observed that zoning generates an increment ranging from 5.4% to 6.3% in average rents, but does not affect the house growth. In addition, we conducted sensitivity analysis that suggests that this result is not simply driven by unobservable confounders. Our evidence suggests that even being a usually well-intentioned policy, zoning tends to generate social costs that need to be taken into account in the analysis of the real estate market in Brazil.

Keywords: Land Use Restrictions, Urban Zoning, Urban Development, Brazil.

Código JEL: R31, R52, L51.

Área 10 – Economia Regional e Urbana

1. Introduction

In recent decades, a sharp increase in population concentration took place in major Brazilian metropolitan areas, continuing the rapid urbanization process that has been occurring in Brazil over the last century. For example, the population density of the metropolitan region of Sao Paulo grew 12.7% between 2000 and 2010. In new metropolitan areas such as Brasilia and Goiania, the population density increased by 23.7% and 22.7%, respectively (Brazilian Demographic Census 2010). Due to higher population density around cities and macroeconomic stability, which increased housing credit, the Brazilian real estate market underwent a price boom. According to the Fipe Zap index, which measures the selling price of properties and rentals in main Brazilian cities on a monthly basis, from 2010 to 2015, housing prices increased 223.5% in Sao Paulo, whereas rents increased at a rate of 100.8%. This variation was significantly higher than inflation in the same period, which reached 54.6% (measured by IPCA).

In addition to demand-related factors, supply-related factors such as the higher cost of real estate development and the restrictions in urban land use may have also a connection with this great appreciation of the Brazilian real estate market. One of the main ways to regulate and restrict urban land use in Brazil is through zoning ordinances. Zoning ordinances are instruments of urban planning and management which are usually established by local governments and can regulate both the type of use (establishing residential areas, commercial areas, industrial or mixed) and the intensity of use, to restrict the size, the weight of buildings or the flood-area ratio (McDonald and McMillen 2012). Note that, in addition to traditional zoning, there are other regulations that can be used to restrict urban land use, such as the minimum lot size requirements, rules governing septic systems, subdivision requirements, wetland regulations, green area requirements and others (Fischel, 2004; Glaeser and Ward, 2009).

In Brazil, local governments (municipalities) are in charge of the adoption and the management of land use controls. These instruments have gained greater relevance in the late 70s and thus became regulated by federal laws. For example, in 1979, a federal law that regulates urban land parceling (Federal Law 6766/79) came into force. A key feature of this law is that it establishes a minimum lot of 125 square meters and, in addition, delegates to municipalities the autonomy to set their own guidelines for the allotment and the breakup of land. In 2001, the federal government created the "*Estatuto da Cidade*" (Federal Law 10257/01), a law that established general urban guidelines and the obligation of master plans for a set of municipalities. In this context of federal regulation on urban planning instruments, a large increase in the number of municipalities that have their own zoning ordinance occurred: in 1978, only 64 municipalities had regulations for the urban land; in 2013, this number rose to 1,724 (Munic 2013). Despite the recent increase in the adoption of these regulations, little is known about their impact on the Brazilian housing market. In this study, we will take advantage of the variability of the law between the municipalities to assess their impact on the average rental prices and on the real estate market growth.

According to McDonald and McMillen (2012), the objective of the supporters of the law is to protect the residents' well-being from the adverse effects of industrialization, rapid and intense urbanization and high-impact buildings. Therefore, zoning would be useful to reduce the negative externalities that are associated with certain types of land use or degrees of use. However, by restricting the land use and limiting new developments, urban zoning ends up bringing changes to the land market and consequently may increase the prices of existing buildings and residences (Quigley 2007; McDonald and McMillen 2012). Thus, it creates a great incentive for homeowners to support, defend and claim for zoning laws (or other restriction instruments) with the aim of increasing the price of their houses, even in the absence of actual negative externalities (Quigley 2007; Fischel 2004).

A large number of empirical studies investigates the impact of zoning and land use restrictions on the housing and urban land market. Quigley and Rosenthal (2005), Quigley (2007) and McDonald and McMillen (2012) make a detailed review of these studies. Even with different empirical strategies and analyzing different metropolitan areas in the United States, these papers show a similar conclusion: the degree of land use restrictiveness is positively correlated with property price and negatively correlated with new real estate developments (Quigley and Raphael 2005; Ihlanfeldt 2007, Glaeser and Ward 2009; Zabel and Dalton 2011). Additionally, there is evidence that lot price is higher in more regulated areas (Kok,

Monkkonen and Quigley 2014) and that cities with more strict regulation suffer from a greater amplitude in the house price cycle, with more intense booms and bursts (Huang and Tang 2012).

The major empirical challenge of those papers is to solve the potential endogeneity in the relationship between zoning and real estate prices. Typically, to overcome this problem, some studies add a wide range of control variables (Glaeser and Ward 2009 and Kok, Monkkonen and Quigley 2014), add fixed-effects (Zabel and Dalton 2011) or employ an instrumental variable approach (Ihlanfeldt 2007). However, not all omitted variables can be measured or are fixed in time, which weakens the first approach. Moreover, it is extremely difficult to find an instrument that satisfies the exclusion restriction. For example, Ihlanfeldt (2007) received criticism for using past demographic characteristics as an instrument to the current level of land use restrictiveness. It turns out that past demographics can be correlated with other current characteristics that affect property price, weakening the exclusion restriction (Glaeser and Ward 2009). In addition to this unresolved empirical difficulty, another limitation of those studies is that they focus only on the US housing market. However, due to the recent urbanization process, the real estate market of developing economies can behave in a very divergent way (Alterman 2013), so that the conclusions of such papers cannot be easily extended to these countries.

This paper contributes by analyzing the Brazilian case, where, unlike the United States, the urbanization process only took off in the second half of the twentieth century. In addition, this study deals with endogeneity in a different way: rather than trying to solve the problem thoroughly, we will evaluate how robust is our evidence in the presence of endogeneity caused by omitted variables. In this sense, considering our goal of investigating the effect of zoning in average rent prices and in the real estate market growth, we employ a Propensity Score Matching (PSM) estimator and sensibility analysis proposed by Rosenbaum (2002) and by Ichino, Mealli and Nannicini (2008). Furthermore, another contribution of our study is to use a measure of rental prices, which is adjusted by the property's characteristics. Our results reveal that municipalities that adopt zoning as an urban planning policy have an average rental price 5.4% to 6.26% higher than that of similar municipalities that do not adhere to the order. A sensitivity analysis based on Rosenbaum bounds indicates that for our evidence to be invalidated there must be an unobservable variable that increases the odds in zoning adoption by 90% and is strongly correlated with the rental price. Moreover, the sensitivity analysis proposed by Inchino et al. (2008) shows that even if there are important confounders, our result remains valid. Thus, the sensitivity tests point that our evidence is not driven by endogeneity. Additionally, we also found that the zoning law is not able to affect the real estate market growth, suggesting that higher rental prices are not simply a reflection of a lower housing supply.

The paper is organized as follows: in Section 2, we discuss the evidence of previous literature that assess the impact of land use restrictions in the perspective of developing economies. In Section 3, we present the institutional background and the origins of zoning in Brazilian municipalities. Section 4 details the empirical strategy. Section 5 describes the data, the covariates and the procedure for constructing a constant quality rental price; Section 6 presents the main results and robustness tests and, finally, Section 7 presents the final considerations.

2. Zoning in developing countries: empirical evidence

In developing and recently urbanized countries, policies that restrict land use or that control the intensity of use have consequences on the housing market that can differ substantially in relation to developed countries' markets (Alterman 2013). Firstly, strict regulations with low enforcement power (which is common in developing countries) may generate a low level of compliance and therefore little influence in land and property prices. In addition, stricter regulations - by increasing the price of real estate development and reducing the supply elasticity of available lots - can cause an additional incentive to low-income households decide to enter in the informal housing market and, thus, there is an increase in slums formation and in the number of low quality settlements (Cavalcanti and Da Mata 2013). Furthermore, the motivations for the regulation can also be different. For example, in countries with lower income levels, the land-use restrictions can be used as a way to prevent strong densities, which could generate an overload in the poor urban infrastructure (Brueckner and Lall 2015).

In a study conducted for Argentina, Monkkonen and Ronconi (2013) detected that in municipalities with more stringent regulations, both the level of compliance and the price lots were smaller. Although the

negative correlation between the restrictions in urban land use and prices is counterintuitive in the face of the US cities' evidence, the authors argue that by stimulating the growth of low quality houses and slums, land-use restrictions cause negative externalities in the neighborhood and, therefore, the lots suffer devaluation. In a descriptive study for the Offinso South Municipality, in Ghana, Boamah (2013) shows that the land-use regulations have little practical effect, since most of the developers do not comply with the order. According to the author, this is a common situation in African cities and it happens because the planning laws have a low enforcement level, are poorly adapted to local conditions and are guided by public offices with high levels of corruption. Similar results were found by Arimah and Adeagbo (2000) for a Nigerian city.

Although the low applicability of planning laws is an important point in the debate about the effects of zoning in cities in developing countries, the consequences regarding housing affordability and slum formation have an even greater importance on the well-being of citizens. According to UN-Habitat (2003), about 30% of the world's urban population lives in slums, where, due to the poor condition of public infrastructure and low-quality housing, the quality of life of dwellers is very low. Some studies sought to verify the impact of the land-use restrictions on the growth of the informal housing market, considering the Brazilian case. In this sense, Biderman (2007) argues that the formal housing market is very connected to the informal ones. The author also shows evidence that there has been an increase in informality in Brazilian municipalities that have adopted zoning rules in the 1990s. More recently, Cavalcanti and Da Mata (2013), through a structural general equilibrium model, show that much of the 1980-2010 slum growth in Brazil is connected with rural-urban migration, with an increase in income levels and in the restrictiveness of land-use regulations.

Perceiving that land-use restrictions can increase house prices and, thus, worsen the welfare of poor households, some governments use inclusionary zoning as a way to generate affordable housing. However, despite being well intentioned, this policy does not always attain the desired effects. For example, investigating Brazilian cities, Lall, Wang, and Da Mata (2007) show that in municipalities that have adopted urban policies targeted at reducing the minimum lot size, there was an increase in the formal housing supply and an increase in population growth (via migration). Once the population growth was higher than the formal housing growth, the policy also caused an undesirable effect: an increase in slum formation. This evidence is in line with the work of Schuetz, Meltzer and Been (2011) showing that policies that aim to produce affordable houses through inclusionary zoning can also generate the opposite effect: higher prices and lower production rates.

At this point, it is necessary to recognize that as one of the main instruments for urban planning, land-use restrictions and zoning affect many other aspects of the cities' dynamics, going far beyond the effects on the housing market. In a study for Indian cities, Brueckner and Sridhar (2012) found that municipalities with stricter building height limits have larger spatial sizes. The authors show that a unity increasing in the floor-are ratio (FAR) limit can generate a reduction of approximately 20% of the area of an average city, which generates a yearly savings in commuting costs of about 0.7% of the annual income of a typical household.

As can be seen by the above discussion, the majority of empirical studies focuses on assessing the impact of the urban land regulations on indirect outcomes, such as the informal housing market. However, for regulations to affect this type of market, it is first necessary to prove that regulations also affect the prices of the formal housing market. Without this, the previous evidence is not very credible. Regarding the Brazilian case, little is known about the consequences of zoning in relation to rental prices or property prices. As far as we know, the study of Duarte, Silveira-Neto and Sampaio (2015) for the city of Recife (the center of the fourth largest metropolitan urban area of Brazil) is the only exception. More specifically, the authors investigated the price effect of a law that restricts the height of the buildings in a particular area of the city. Through a Differences-in-Differences strategy, the authors showed that the new ordinance had caused an increase of about 6% in the price of properties located in the area in which the ordinance was implemented. However, since this paper analyzes a municipal policy made for a relatively small area, it lacks external validity. In order to generalize the effect of land-use restrictions in Brazil, it is necessary to investigate the problem in a broader perspective. This study aims to fill this gap.

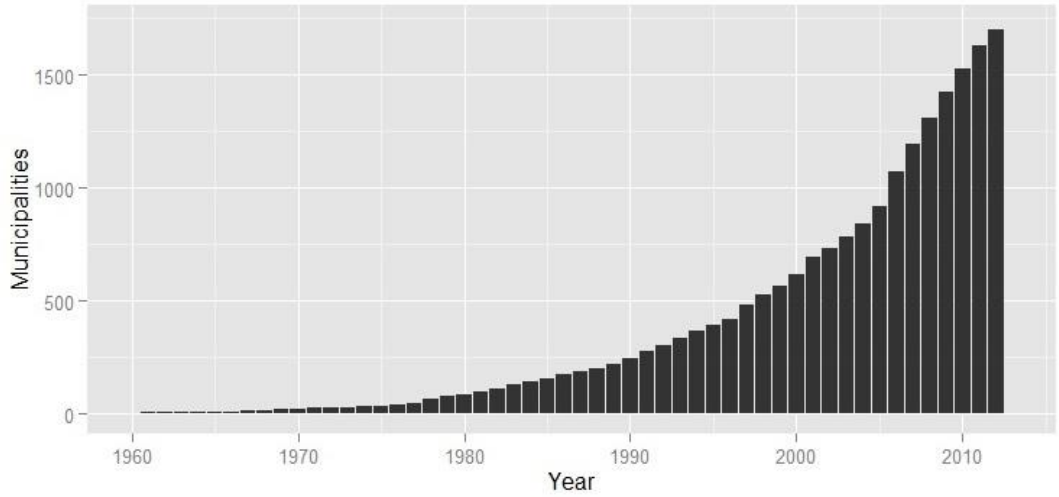
3. Zoning and Urban Planning in Brazil: Historical and Institutional Background.

Brazil is a country with relatively recent urbanization: in 1940, only 31.2% of the population lived in urban areas. That number grew throughout the century, rising to 84.3% in 2010 (Census 2010). This rapid urbanization process, linked to the industrialization of the country, brought a number of problems for the Brazilian cities. Not surprisingly, it becomes necessary to introduce some urban planning instruments. In Brazil, because of its federative character, the local governments (municipal level) are responsible for creating and establish their own planning laws. It was only at the end of the 1970s that the federal government has assumed a coordinating role in urban issues involving municipalities.

Initially, the first urban regulations used in the country consisted in building codes and limited ordinances. They were deployed in the cities of Rio de Janeiro and Sao Paulo in the late nineteenth century, and, in many cases, resembled zoning rules with a more restricted coverage area. These instruments were demanded by high-income population, who used it as a way to defend their properties' value against the aggravation of the problems generated by industrialization (Borges 2007). For example, the posture codes of Sao Paulo, created in 1886, prohibited the construction of low-income and working houses in the city's commerce perimeter (Nery Júnior 2013). It was only in the 1930s that urban regulations started being disseminated to other Brazilian cities, such as Recife and Porto Alegre, but were still not comprehensive enough, and thus did not constitute a general rule of zoning.

In the mid-1970s, a spread of general zoning ordinances took place. A milestone is the introduction of the law 7805/72 in São Paulo city, which, among other things, covered the whole territory of the municipality and instituted exclusively residential areas and commerce corridors (Nery Júnior 2013). Figure 1 shows the evolution in the number of municipalities that adopted their own zoning ordinance: in 1960, for example, only six cities had land use regulations.

Figure 1 - Evolution of the number of municipalities with zoning ordinances.



Source: The authors, based on MUNIC 2013 data.

In addition, it can be observed that, from the 198s on, there has been a great increase in the number of municipalities that have adopted zoning as an urban management instrument. Several interrelated factors can explain this growth. Firstly, it may be a natural consequence of the ongoing urbanization process in the country: in 1980, about 67.5% of the population already lived in urban areas. Moreover, in line with Gyourko, Saiz, and Summers (2008), the increase in wealth and education of Brazilian citizens can explain a greater awareness of the intensity and the use of the urban land. At that time, some institutional changes in the country were also associated with greater diffusion of zoning among municipalities. In 1979, the federal government took on a coordinating role of urban policy in cities. In this sense, the Federal law 6799/79 came into force, establishing general rules and guidelines for the division of urban land. This law also established the minimum lot size of 125 square meters, delegating to municipalities the option to adopt stricter criteria. Furthermore, in 1988, a new federal constitution was created, which, because of its

decentralized characteristics, favored the autonomy of the municipalities in formulating their own public policies and the management of fiscal resources.

Due to intense city growth and to rural-urban movements, there was a strong increase in housing demand without a counterpart of the supply, causing a rise in the housing deficit[1] and the formation of slums across the country. To alleviate this problem, and realizing that the urban land restrictions can cause higher housing prices, some municipalities have adopted a kind of inclusionary zoning: the Special Zones of Social Interest (ZEIS)[2]. These are constituted of demarcated areas within the cities with more flexible and more specific rules regarding zoning. Other important institutional framework for the country's urban planning policy is the approval of the Federal Law 10257/01, known as "*Estatuto da Cidade*" which, among other things, emphasizes the social function of property, encourages participatory planning and enforces the adoption of a city master plan by a set of municipalities. This federal law may also have driven the strong adoption of zoning by the cities in the most recent period, from 2000 to 2013, where 1,013 new municipalities have adopted the order (figure 1).

Note that, although the zoning ordinances are present in 1,724 Brazilian municipalities (about 31% of the total), little is known about their impact on the formal housing market. In this work, we will take advantage of the variability of orders between the municipalities to verify the impact of land-use regulations on average rents and on the real estate market growth.

4. Empirical Strategy

4.1 Propensity Score Matching

The aim of this study is to investigate the effect of municipal zoning policies on average rent prices and on the real estate market growth. The great empirical challenge of this kind of analysis is to eliminate the possibility of endogeneity by reverse causality and by omitted variables. Although it is assumed that property prices can be explained by zoning ordinances, the reverse way is also possible: maybe zoning occurs just in areas that have more highly valued houses (Quigley, 2007). To reduce these concerns, we will apply a matching-based strategy in conjunction with a series of sensitivity analyses.

In this sense, our goal is to make a match between treated observations (municipalities that have implemented zoning ordinances) and the control observations[3] (municipalities that have not adopted zoning ordinances) such that the control group can be considered a counterfactual - what would happen to the treatment group had they not adopted zoning. Consider Z a binary variable that describes zoning. Thus, $Z = 1$ if the municipality has implemented the ordinance and $Z = 0$ otherwise. Y_0 and Y_1 describe the potential outcomes that vary according to the treatment (zoning order). In real life, only one of these outcomes can be actually observed for each municipality. However, the causal effect is defined as the difference between Y_1 and Y_0. We are interested in obtaining an estimate of the average effect of the treatment on the treated (ATT), defined as follows:

$$ATT = E(Y_1 - Y_0|Z = 1) \quad (1)$$

Under a set of assumptions, various methods can be used to estimate the ATT. One of these is the Propensity Score Matching (PSM) developed by Rosenbaum and Rubin (1983). The propensity score is the probability of receiving the treatment (in our case, implementing a zoning ordinance) given the observed covariates (defined as the X vector), i.e. $P(X) = P(Z = 1|X)$. The key identification assumption for the ATT is that Y_1 and Y_0 are independents of Z given $P(X)$. In other words, $Y_1, Y_0 \perp Z|P(X)$. This is known as Conditional Independence Assumption (CIA). Additionally, it is also necessary that, for each treated unit, a matched control unit with similar X exists. This assumption is known as overlap condition, and can be

[1] According to calculations of the João Pinheiro Foundation (2010), the housing deficit in Brazil is of 6,490 million housing units.

[2] 920 municipalities adopt the ZEIS through specific legislation, while 1,556 municipalities include the ZEIS as a part of the city master plan (MUNIC, 2013).

[3] In Figure 1A of Appendix, we show the spatial distribution of municipalities by zoning adoption.

written as: $0 < P(Z = 1|X) < 1$. Finally, assuming that the CIA and the overlap condition holds, the impact of zoning on the city's average rental price which implemented the ordinance is given by:

$$\tau_{ATT} = E(Y_1 - Y_0|Z = 1) = E[E(Y_1 - Y_0|P(X), Z = 1)] \\ = E[E(Y_1|P(X), Z = 1) - E(Y_0|P(X), Z = 0)|Z = 1] \quad (2)$$

That is, under these assumptions, we can use the outcomes of matched control municipalities as a counterfactual for the estimation of ATT. A two-step procedure is employed to obtain an empirical counterpart of (2). Firstly, a probabilistic regression model is estimated to get the propensity scores, $P(X)$. Second, based on algorithms, we make a match between the treated and non-treated municipalities which have a similar propensity score. For robustness purposes, we will apply three types of matching algorithms commonly used in the empirical literature: the nearest neighbor, the radius matching and the kernel matching. Caliendo and Kopeinig (2008) describe these algorithms in detail and discuss the advantages and disadvantages (in terms of bias and efficiency) of each one.

4.2 The plausibility of the CIA and sensitivity analysis

The CIA assumption implies that the adoption of zoning is completely explained by observable variables. That is, the matching procedure is constructed by using all covariates that generate differences in the distribution of treated and non-treated units, making the probability of treatment equal between the matched pairs, as if there had been a random assignment (Caliendo and Kopeinig, 2008). Thus, it is essential that the vector X contain detailed information on the relevant characteristics of municipalities, which will be possible with the Brazilian Demographic Census and the Survey of Basic Municipal Information (MUNIC). We will describe the variables used to obtain the propensity score in the next subsection.

However, even with detailed information on the municipalities, there is a possibility that the CIA is not valid due to the existence of unobservable variables (confounders) that affect both the adoption of zoning and the outcome variable. The existence of confounders can make the ATT estimator biased and therefore hardly credible - this is the weakness of PSM strategies. Although the CIA is, by construction, a non-testable assumption and the absence of confounders is little convincing, we can - through a sensitivity analysis – either evaluate the strength that an omitted variable must have to invalidate our ATT estimate or simulate potential confounders. In this sense, we will use two different kinds of sensitivity analysis (Rosenbaum, 2002 and Inchino et al. 2008) to verify the robustness of the ATT when the Conditional Independence Assumption fails.

Firstly, we will apply the sensitivity analysis developed by Rosenbaum (2002), which provides an indication of the magnitude of the omitted variable bias that would be necessary to invalidate the associations initially observed by the estimated ATT. This method is based on the parameter Γ, which measures the difference in odds of receiving the treatment between observations with the same observable characteristics. Therefore, a random experiment ensures $\Gamma = 1$, and when that Γ grows, the experiment becomes more distant from randomization. For example, in an observational study, if $\Gamma = 3$, then one of the units has three times as likely to receive the treatment due to unobservable factors, since the treated and untreated units are identical regarding the observable variables. Thus, the basic procedure for Rosenbaum sensitivity analysis is to select a series of Γ values and, for each one, calculate a bound of significance level (p-values) for the ATT in the case of a endogenous treatment selection (Diprete and Gangl 2004).

In addition, we will also apply a sensitivity analysis proposed by Ichino et al. (2008). This strategy aims to verify the bias of the estimated ATT when the CIA fails in some specific and relevant way. First, it is necessary to establish values for the parameters that characterize the distribution of a specific confounding factor, denoted by U. It's assumed that this variable is binary, independent and identically distributed. Thus, the distribution of U is completely characterized by the choice of four parameters, denoted by p_{ij}:

$$p_{ij} \equiv \Pr(U = 1|Z = i, I(Y > \bar{y}) = j) \quad (3)$$

Where $i, j \in \{0,1\}$, I is an indication function and $\bar{y}$ is the mean of the outcome variable. Based on the parameters defined by (3), a value of U is given for each treated and control observation in accordance to one of the four groups to which the observation belongs. The simulated U is considered as a new observable covariate and is then included in the set of variables used for the matching process. Finally, the ATT is computed again with the inclusion of confounder U. Therefore, by modifying the parameters that characterize the distribution of U, we can evaluate the robustness of the ATT against different assumption related to the nature of confound factor (Nannicini, 2007).

We will follow the simulation exercises proposed by Ichino et al. (2008) and choose p_{ij} in order to make the confounder distribution similar to the empirical distribution of important covariates. Furthermore, the confounders will be simulated to be threatening to the baseline ATT: will have positive correlation with the treatment status variable (Z) and with the outcome of non-treated units.

5. Variables and Data

This section describes the construction and choices of the variables that will be used to implement the empirical strategy discussed above. More specifically, in subsection 5.1, we discuss the database employed in the paper and the main motivations for the covariate choices. Moreover, in the subsection 5.2, we will argue over the importance and the procedure to discount the property attributes from the respective rental price, in order to get a cleaner outcome variable.

5.1 Database and Covariates

As previously discussed, our empirical strategy will take advantage of the fact that some municipalities have adopted zoning ordinance while others do not. Information on urban policies that each city adopts are obtained from the survey of Basic Municipal Information (MUNIC), a database elaborated annually by the Brazilian Institute of Geography and Statistics (IBGE) to gather information on the dynamics, structure and functioning of local institutions. Thus, our treatment variable is dichotomous and takes the value of one if the municipality had a zoning law in 2004[4], and takes the value of zero otherwise. For robustness purposes, we also employ other treatment variable that measures the degree of rigidity of the minimum lot size endorsed by the municipality. It will take the value of one in the case of the local administration set a minimum lot size greater than 125 m² and zero otherwise.

Regarding the outcome variables, we will use two throughout the paper: the average rental prices (measured in 2010 and adjusted by the property quality) and the growth of formal houses in the 2000-2010 period. We will follow the Caliendo and Kopeing (2008) recommendation, and add only covariates that simultaneously affect the outcomes and the zoning adoption. To ensure that these variables are not directly affected by the treatment, they will be fixed in time or measured before the treatment (year 2000). The outcomes and the control variables were obtained from the Brazilian Demographic Census of 2000 and 2010. It is necessary to point out that since our outcome variable was measured only in 2010, it is impossible to build a panel database.

The choice of the control variables that will be used to proceed with the matching between the municipalities that adopt zoning and those that do not adopt was based on recent empirical literature (e.g. Ihlanfeldt 2007, Glaeser and Ward 2009; Zabel and Dalton 2011; Monkkonen and Ronconi 2013; Kok, Monkkonen and Quigley 2014). We split the covariates into five - not mutually exclusive - sets: I) Demand Factors: characteristics that drive the intense use of urban land, such as population density, population growth (1991-2000) and per capita income; II) Externalities Factors: activities that inflict damage to the natural and social environment of cities, causing greater pressure for the adoption of urban planning laws, which include urbanization and industrialization rate; III) Demographics: since the zoning orders are set by municipal legislators, local citizens have a strong influence on the conduction of urban policy. In this sense, we include the following variables: average years of schooling, the percentage of blacks, of working age,

[4] We opted to choose this particular year because the information available in the MUNIC 2004 is consistent with each consulted local zoning order. Information about zoning are also collected in MUNIC 1999, 2005 and 2009. However, for these surveys there is some degree of disagreement with the local zoning orders. Anyway, in section 6.3, we will evaluate the robustness of the results to changes in the treatment assigned in the 1999, 2005 and 2009 MUNIC.

immigrants, voter's turnout and percentage of homeowners; IV) Urban Infrastructure: as discussed in section 2, policies that restrict the urban land use can be simply a way to avoid high densities in places with poor urban infrastructure, thus we include the following variables in the control set: percentage of households with sewage, with electricity and pipe water; V) Environmental and Fixed Factors: urban planning can also be established in order to protect the natural and cultural heritage from the real estate development. Thereby, cities that have coastline, units of natural conservation or historical-cultural capital may be more likely to adopt zoning orders. Therefore, we will use the year the city was founded as a proxy for the historical-cultural capital, coastline and conservation area dummies, and finally, the distance to the nearest capital city. In addition to these sets of covariates, we will also include state-fixed effects in the propensity score estimation. The use of this broad set of variables that characterize the municipalities aims to make the distribution of treated and untreated municipalities as similar as possible. However, it is very likely that there are unobservables that affect the zoning assignment. Our argument in this study is that these variables are not important enough to invalidate our results. In the next section, we will discuss the main evidence of the work.

5.2 Constructing constant quality rental prices

An important concern in our analysis is the possibility that zoning occurs in cities with better housing standards. In this case, a positive relationship between zoning and average rental price could reflect only a simple association between prices and their hedonic attributes. In this study, we will use the correction proposed by Quigley and Raphael (2005), which seeks to adjust the rental prices in relation to property characteristics. This strategy aims to eliminate the influence of residences attributes of their respective rental prices, in order to obtain an average rent that only reflects the city's characteristics.

Therefore, the first step is to estimate a hedonic regression for each Brazilian municipality (5,507 separate regressions), where the dependent variable is the rental price and the independent variables are the properties characteristics available in the Demographic Census of 2010: number of rooms, number bathrooms, number of other rooms and a dummy that takes the value of one if the house is made of bricks and zero, otherwise (Seabra and Azzoni 2015). The dwelling is the observation unit in this analysis. In Appendix, the Table A1 summarizes the mean of the estimated coefficients. As expected, all the hedonic characteristics affect the rental prices positively. The last step is to combine the estimated coefficients of each city with the average hedonic characteristics of Brazil, in order to estimate the average rental price with constant quality. This will be our main outcome variable.

6. Results

In this section, we will present and discuss the results obtained by applying the methodology described above. First, we will evaluate the matching quality and estimate the ATT considering different algorithms (subsection 6.1); then, we will conduct sensitivity analyses (subsection 6.2); and, finally, present some extensions and robustness checks (subsection 6.3).

6.1 Baseline Results

Table 1 shows the means of covariates by treatment status before and after the application of matching procedure. Initially, we can see that cities that adopt zoning order are substantially different from those that do not. For example, regulated cities have a higher per capita income, higher population density, are more urbanized, supply a better infrastructure, are closer to the state capital and also have more natural amenities. It is noted that the mean difference for all observable characteristics is large and statistically significant between the two types of cities. This shows that a simple mean difference of rental price between municipalities with and without zoning is useless for impact evaluation.

For this reason, is necessary to proceed with the matching between municipalities. The columns (5) and (6) of Table 1 show the covariates' means after application of a nearest neighbor matching algorithm with replacement and imposing a common support. 35 treated municipalities (0.63% of the total group) were outside of the common support region and, therefore, were excluded. We can see that after the matching, the characteristics of both kinds of municipalities become very similar, so that there were no statistically significant differences[5]. This evidence suggests a good matching quality.

Table 1 – Mean characteristics of cities that adopt zoning (treated) and that do not (control)

Variable Name	All	Before Matching			After Matching		
		Treated	Control	Difference	Treated	Control	Difference
Log Income (Per Capita)	5.660	6.104	5.511	0.593**	6.086	6.070	0.015
Log Population Density	3.149	3.866	2.908	0.958**	3.777	3.732	0.045
Population Growth (91-00)	0.090	0.130	0.077	0.053**	0.128	0.116	0.012
% Workers in Industrial Sector	0.156	0.213	0.137	0.077**	0.213	0.209	0.004
Urbanization Rate	0.589	0.715	0.546	0.169**	0.708	0.703	0.005
% Immigrants	0.362	0.436	0.338	0.098**	0.434	0.425	0.009
% Homeowners	0.769	0.752	0.774	-0.022**	0.752	0.756	-0.004
% Working-Age population	0.391	0.433	0.376	0.057**	0.432	0.433	0.000
% Black Population	0.058	0.047	0.062	-0.016**	0.047	0.048	-0.002
% Households with Pipe Water	0.581	0.691	0.544	0.147**	0.685	0.692	-0.007
% Households with Electricity	0.869	0.952	0.841	0.111**	0.951	0.954	-0.003
% Households with Sewage	0.228	0.302	0.204	0.099**	0.297	0.294	0.003
Avg. Schooling of 25 years old	4.037	5.121	3.673	1.448**	5.057	5.053	0.004
Turnout in Mun. Elections	0.867	0.874	0.865	0.010**	0.875	0.877	-0.002
Year of Mun. Foundation	1961.8	1957.4	1963.3	-5.900**	1957.8	1959	-1.200
Distance to the State Capital	253.183	233.520	259.860	-26.340**	237.400	245.360	-7.960
Coastal Municipality (1/0)	0.049	0.088	0.036	0.053**	0.079	0.096	-0.017
Conservational Area (1/0)	0.127	0.264	0.081	0.183**	0.249	0.244	0.005
Number of Observations	5498	1386	4112	-	1351	4112	-

Note: For the described matching, we used the nearest neighbor propensity score with replacement and imposing common support area.
*** p< 0.01, ** p < 0.05, *** p < 0.1.

Table 2 summarizes the results of the propensity score estimation. We used a logit probability model with state fixed-effects. Although the choice of a probabilistic model is not critical to the ATT estimation, when compared to the probit function, the logit function has more density mass in the bounds (Caliendo and Kopeing 2008). We note that most of the estimated coefficients take the expected signs based on what

[5] We also use 27 state dummies to build the matching sample of Table 1. The results have been omitted for space constraints, but reveal that the mean difference (with respect to these variables) is not statistically significant between the two kinds of municipalities.

has been discussed above and are consistent with the descriptive statistics of Table 1. Cities with higher income and more educated individuals are more likely to adopt zoning as an urban planning law, which conforms to Gyourko, Saiz, and Summers (2008). Areas that have a greater demand for land use (measured by population density), are more urbanized, which have a higher manufacturing share, and, a precarious urban infrastructure also adopt zoning more easily. This last fact suggests that, Brazilian cities may be using the zoning law as a legal instrument to limit development in areas with poor infrastructure. Finally, the evidence in Table 2 also points a positive correlation between the use of zoning and the existence of natural amenities.

Table 2 - Propensity Score Estimation: Determinants of Zoning

Dependent Variable: Zoning (1/0)	Coefficient	Std. Err.
Log Income (Per Capita)	0.724***	0.219
Log Population Density	0.314***	0.053
Population Growth (91-00)	0.273	0.213
% Workers in Industrial Sector	0.589	0.533
Urbanization Rate	0.656*	0.360
% Immigrants	-0.312	0.462
% Homeowners	-0.805	0.549
% Working-Age population	-0.647	1.044
% Black Population	0.036	1.197
% Households with Pipe Water	-0.128	0.299
% Households with Electricity	-1.484***	0.634
% Households with Sewage	-0.351	0.262
Avg. Schooling of 25 years old	0.702***	0.091
Voter Turnout in Mun. Elections	-2.778***	0.844
Year of Mun. Foundation	-0.001	0.003
Distance to the State Capital	0.001**	0.000
Coastal Municipality (1/0)	0.585***	0.198
Conservational Area (1/0)	0.568***	0.114
Constant	-4.085	5.397
State Fixed-Effects	Yes	
Pseudo R^2	0.32	
Log Likelihood	-2111	

Note: The dependent variable is an indicator for zoned municipalities. The estimation was carried out with a logit function. *** p< 0.01, ** p < 0.05, *** p < 0.1.

After obtaining the propensity scores, we will calculate the impact of zoning on the average rental prices and the real estate market growth using four different matching algorithms. Table 4 shows the estimated ATT and the corresponding measures of matching quality suggested by Rosenbaum and Rubin (1983). In this case, the pseudo R^2 is obtained by estimating the propensity score using only the matched sample. It can be seen that for any of the matching algorithms, we obtain low values of pseudo R^2 and mean standardized bias. For example, considering the nearest neighbor algorithm (column (1)), the mean standardized bias dropped by about 90.8%[6]. These results support those obtained in Table 1, demonstrating that, in fact, it is perfectly possible to build groups of reasonably similar municipalities.

The estimated ATTs vary from 0.054 to 0.062, indicating that cities that adopt zoning as urban planning policy have an average rent 5% higher compared to the non-adopters. This effect is substantial, since it corresponds to about 12.46% of the unconditional difference of average rental between the two kinds of municipalities. Based on our discussion of Section 2, this evidence shows that the zoning orders drawn up by Brazilian municipalities have some level of compliance. In addition, the positive impact of zoning on prices is also in line with the empirical literature that, when analyzing American cities, found

[6] The mean standardized bias before the matching is 32.4.

positive associations between higher levels of land-use restrictiveness and real estate prices. (Quigley and Raphael 2005, Ihlandfeldt 2007, Zabel and Dalton 2011).

Table 3 – The Impact of Zoning on Average Rental Prices and on Real Estate Market Growth

Panel A: Average Rent Prices	(1)	(2)	(3)	(4)
	Nearest Neighbor	10 Nearest Neighbor	Radius	Kernel
ATT	0.05393**	0.05848***	0.06013**	0.06268***
	(0.0212)	(0.0191)	(0.0218)	(0.0201)
	[0.0164]	[0.0110]	[0.0113]	[0.0098]
Bias After Matching	3.1	1.5	1.8	1.6
Pseudo R^2	0.015	0.009	0.008	0.008
Panel B: House Growth	(1)	(2)	(3)	(4)
	Nearest Neighbor	10 Nearest Neighbor	Radius	Kernel
ATT	-0.0094	0.0071	0.0012	0.0079
	(0.0393)	(0.0280)	(0.0265)	(0.0255)
	[0.0356]	[0.0297]	[0.0284]	[0.0253]
Bias After Matching	3.7	2.4	2.7	2.6
Pseudo R^2	0.019	0.009	0.01	0.008

Note: Analytical and bootstrap standard errors (200 interactions) are reported in round and square brackets, respectively. The Radius matching uses a 0.01 caliper and the Kernel matching is constructed using an Epanechnikov function. *** p < 0.01, ** p < 0.05, *** p < 0.1. The average rent prices are corrected by their hedonic attributes (subsection 5.2).

The panel B of Table 3 shows that, regardless of the matching algorithm used, the zoning law does not affect real estate market growth. Therefore, we cannot associate the higher rental prices simply to a reduction in housing supply. There is a variety of mechanisms that can explain the causes of larger rental prices in regulated cities. For example, the need to comply with parameters and building codes can generate higher development costs (Quigley 2007), higher land prices (Kok, Monkkonen and Quigley 2014), or the land-use regulation can reduce housing supply elasticity, which favors large increases of prices in response to variations in demand. In addition, zoning can function as a kind of insurance against conflicting land uses, thus causing an appreciation of proprieties (Zhou, McMillen and McDonald 2008). While understanding the mechanisms that underlie the relationship between zoning and higher prices is important, the aggregated nature of our database does not allow inferences in this way.

Coming back to the ATT estimative on the average rental prices, how reliable are our estimates? The answer will depend on how the estimated ATTs change against failures in Common Independence Assumption (CIA). We believe that, even including important covariates to the propensity score estimation, there are unmeasurable variables that affect both the outcome variable and zoning adoption. For example, the degree of concern of municipal governments with issues related to urban planning is not measurable and is a potential confounding factor that can invalidate the CIA. In the next subsection, we will conduct different kinds of sensitivity analysis.

6.2 Sensitivity Analyses

Firstly, we employ the Rosenbaum (2002) bounds approach to measure the sensitivity of the baseline specification when our key assumption (CIA) is relaxed. Thus, we use different values of Γ -which measures the difference in odds of receiving the treatment between observations with the same observable characteristics - to verify changes in inference due to the existence of unobservable confounders. Table 4 shows the results for Γ ranging from 1 to 2 and the corresponding p-value bounds.

It can be seen that up to $\Gamma = 1.8$, the estimated ATT remains statistically significant at the usual level of 5%. This indicates that a city may have a chance to adopt zoning 80% higher than the others due to unobservable characteristics and yet, our initial evidence remains reliable. Only when $\Gamma = 1.9$, the ATT is no longer significant at the usual levels. Thus, for the higher rental prices to be associated with a unobservable variable instead of zoning order, it is necessary that this confound increase by 90% the odds

of a municipality implement the zoning. Consequently, the results of Table 3 cannot be explained by a simple moderate omitted-variable bias.

Table 4 - Sensitivity Analysis I: Rosenbaum Bounds

Average Rent Prices					
Γ	p-crit+	p-crit-	Γ	p-crit+	p-crit-
1.00	0.000	0.000	1.55	0.000	0.000
1.05	0.000	0.000	1.60	0.000	0.000
1.10	0.000	0.000	1.65	0.001	0.000
1.15	0.000	0.000	1.70	0.004	0.000
1.20	0.000	0.000	1.75	0.014	0.000
1.25	0.000	0.000	1.80	0.039	0.000
1.30	0.000	0.000	1.85	0.088	0.000
1.35	0.000	0.000	1.90	0.170	0.000
1.40	0.000	0.000	1.95	0.285	0.000
1.45	0.000	0.000	2.00	0.426	0.000
1.50	0.000	0.000			

Note: the parameter Γ measures the odds of receiving the treatment considering municipalities with the same observable characteristics. The method is built based on the nearest neighbor matching without replacement.

The results of the sensitivity analysis proposed by Inchino et al. (2008) can be seen in Table 5. We choose values of p_{ij} in order to simulate confounders with distributions analogous to those of the observed covariates and that have a positive correlation with treatment and outcome variables[7]. This way, we simulated unobservables with a similar distribution of the following variables: per capita income, population density, urbanization rate, average schooling, conservation area and coastal municipality dummy. It is worth mentioning that the Inchino et al. (2008) procedure assumes that the distribution of simulated confounder is discrete[8]. Thus, to mimic the continuous covariates, we use the following criteria: the simulated binary variable will take the value of one if its value is above the mean (or median) of the distribution, and zero otherwise.

Table 5 - Sensitivity Analysis II: Simulated Confounders

	p11	p10	p01	p00	Out. Eff.	Selec. Eff,	ATT	SE
Baseline	0	0	0	0	-	-	0.054***	0.021
Neutral	0.5	0.5	0.5	0.5	1.019	1.006	0.062***	0.008
Confound to Mimic								
Income (Mean)	0.94	0.44	0.76	0.16	17.598	3.713	0.044***	0.010
Income (Median)	0.91	0.35	0.71	0.13	17.736	3.406	0.045***	0.009
Average Schooling (Mean)	0.92	0.43	0.71	0.14	15.146	4.044	0.044***	0.010
Average Schooling (Median)	0.92	0.42	0.69	0.13	15.338	4.075	0.043***	0.010
Density (Mean)	0.71	0.49	0.45	0.45	0.993	2.327	0.062***	0.010
Density (Median)	0.7	0.49	0.44	0.45	0.990	2.300	0.061***	0.010
Urbanization Rate (Mean)	0.77	0.46	0.59	0.32	3.111	2.193	0.055***	0.010
Urbanization Rate (Median)	0.76	0.45	0.58	0.31	3.120	2.190	0.054***	0.009
Coastal City (1/0)	0.09	0.08	0.04	0.03	1.286	2.545	0.062***	0.008
Conservational Area (1/0)	0.29	0.11	0.12	0.05	2.945	2.993	0.058***	0.011

Note: The method is based on nearest neighbor matching with 200 interactions. The outcome effect measures the impact of the unobserved variable on the untreated outcome, while the selection effect measures the impact of the unobserved variable on treatment assignment. *** p < 0.01, ** p < 0.05, *** p < 0.1.

[7] This would be an unobserved variable with potential to explain the positive impact of zoning on rental prices.

[8] Through Monte Carlo simulations, the authors concluded that the assumption that the confounder assumes a discrete distribution when in fact it is continuous is not able to generate erroneous conclusions regarding the sensibility of the ATT. Moreover, Wang & Krieger (2006) show that binary variables are more threatening to causal inference than continuous ones.

From Table 5, it can be seen that when the CIA does not hold due to the existence of a specific unobservable confounder, the magnitude of the ATT changes but remains qualitatively important and statistically significant. For example, even if we are omitting an unobservable that is too important to the adoption of zoning such as per capita income or population density (Alterman 2013, Gyourko, Saiz and Summers 2008), our initial evidence remains valid. These results reinforce the conclusion reached by applying the Rosenbaum bounds, indicating that, in fact, the positive impact of zoning on the average rental price does not seem to be driven by some omitted variable.

6.3 Robustness Checks

In addition to the sensitivity analysis described in the previous subsection, we also verified the robustness against changes in the definition of treatment and outcome variables. Firstly, it was considered a more specific measure of land-use restrictiveness: the minimum lot size. As discussed in Section 2, some municipalities determine a minimum lot size greater than the recommendation of Federal Law 6799/79, becoming more rigid. Thus, we modify the treatment variable to a dummy that takes the value o 1 in case the municipality set a minimum lot size higher than 125m² and 0 otherwise. To get a clearer impact of this regulatory instrument, we dropped the municipalities that already have some zoning ordinance. Thus, the number of municipalities fell to 4,121, where 956 (23.19%) set a minimum lot size higher than 125m². The results of this exercise can be seen in panel A of Table 6.

Table 6 – The impact of Zoning: ATT using different treatment and outcome variables

Panel A: Higher Minimum Lot Size	(1)	(2)	(3)	(4)
	Nearest Neighbor	10 Nearest Neighbor	Radius	Kernel
ATT	0.0381**	0.0301***	0.0284***	0.0351***
	(0.0211)	(0.0169)	(0.0179)	(0.0173)
	[0.0177]	[0.0113]	[0.0107]	[0.0102]
Bias After Matching	2.6	1	0.9	1.2
Pseudo R^2	0.014	0.002	0.002	0.002
Panel B: Average Rent Prices	(1)	(2)	(3)	(4)
	Nearest Neighbor	10 Nearest Neighbor	Radius	Kernel
ATT	0.04607***	0.05125***	0.05112***	0.05462***
	(0.0227)	(0.0198)	(0.0222)	(0.0205)
	[0.0165]	[0.0111]	[0.0105]	[0.0088]
Bias After Matching	3	2.3	2.5	2.4
Pseudo R^2	0.013	0.008	0.008	0.008
Panel C: Median Rent Prices	(1)	(2)	(3)	(4)
	Nearest Neighbor	10 Nearest Neighbor	Radius	Kernel
ATT	0.0295*	0.0398***	0.0407***	0.0442***
	(0.0242)	(0.0207)	(0.0229)	(0.0212)
	[0.0173]	[0.0107]	[0.0096]	[0.0092]
Bias After Matching	3	2.3	2.5	2.4
Pseudo R^2	0.013	0.008	0.008	0.008

Note: In panel A, the treatment variable is modified to a dummy that takes the value of 1 if the municipality adopts a minimum lot size (MLS) greater than 125 square meters and 0 otherwise. In panels B and C, the outcome variable is modified to the average/median rent prices without the hedonic correction. Analytical and bootstrap standard errors (200 interactions) are reported in round and square brackets, respectively. The Radius matching uses a 0.01 caliper and the Kernel matching is constructed using an Epanechnikov function. *** p < 0.01, ** p < 0.05, *** p < 0.1.

The estimated ATT indicates that in municipalities that adopt stricter criteria regarding the minimum lot size, the average rental prices are around 2.84% to 3.51% higher when compared to those who do not. This result is in line with our previous discussion and reveals the robustness of the results to different

treatment criteria. In panels B and C of Table 6, we change the outcome variable to the average and median[9] rental price without making any adjustments to the property characteristics. That is, the rental prices are not measured with constant quality. This robustness test is useful to demonstrate that the adjustment made in the outcome variable, before calculating the zoning impact, was not decisive to find an economically significantly result. In this case, the Figures of panels B and C indicate that there was a reduction in the magnitude of the estimated ATT. However, the results remain economically important, indicating robustness.

Finally, as argued in subsection 5.1, we chose to use the treatment assignment (zoning) based on the MUNIC survey of 2004. Data about zoning ordinances were also collected in MUNIC 1999, 2005 and 2009. However, among these surveys, there are some divergences regarding the information about the municipality zoning adoption. The 2004 survey has a higher degree of compliance with local laws, inspected manually. For this reason, this survey was chosen to define the municipalities that have zoning ordinances. Anyway, to demonstrate that our result was not driven by this choice, we also estimate the ATT modifying the treatment criterion to that one's defined on MUNIC 1999, 2005 and 2009. The results are displayed in table 2A of Appendix (Panels A, B and C). In panel D of Table 2A, the assignment is defined as follows: the municipality is treated (has zoning ordinances) if defined in at least one of MUNIC surveys. The result of table 3A shows that although there is a significant variation in the estimated ATTs, the results remain significant and economically relevant. That is, our conclusion is not sensitive to different MUNIC surveys.

7. Conclusions

In recent decades, due to the increased autonomy of local governments, the rising of income and a greater federal concern with urban planning issues, there has been, in Brazil, the diffusion of the idea of the urban land-use regulations. In this context, the number of cities with zoning law has grown from 64 in 1978 to 1,724 in 2013. Nevertheless, little is known about the impact of these local policies on the functioning of the Brazilian real estate market. Our study sought to contribute to this debate.

To reduce concerns about the endogeneity in the relationship between zoning and prices, we use a strategy based on the Propensity Score Matching (PSM). However, a necessary assumption is that the adoption of zoning is determined only by observable characteristics. This hypothesis, known as Conditional Independence Assumption (CIA), is little credible. Thus, through sensitivity analysis (Rosenbaum 2002, Inchino et al. 2008), we evaluate how our findings are robust to failures in the CIA. The results indicate that zoning generates an increase in the average rental price by 5.4% to 6.3%. Moreover, this evidence was robust to different matching algorithms, to the fails in CIA and, also, to changes in the definition of the outcome and treatment variables.

The fact that the cost of housing is higher in cities that restrict land use is consistent with previous studies showing that regulations favored the development of the informal housing market and slum formation (Biderman, 2007, Cavalcanti and Da Matta 2013). Facing a higher price in the formal housing market, low-income households tend to migrate to the informal ones. Consequently, there is a welfare loss, since this type of market is characterized by poor urban infrastructures. In this way, zoning ordinances can be generating social costs that are not negligible. In terms of public policy, it is necessary that programs aimed to finance affordable housing also consider the degree of land use restrictiveness in the municipalities. Areas with more intense zoning may have a wider coverage of these policies, in order to offset the adverse effects of land-use restrictions.

[9] Unlike the average rent, the median rent is less sensitive to extreme values.

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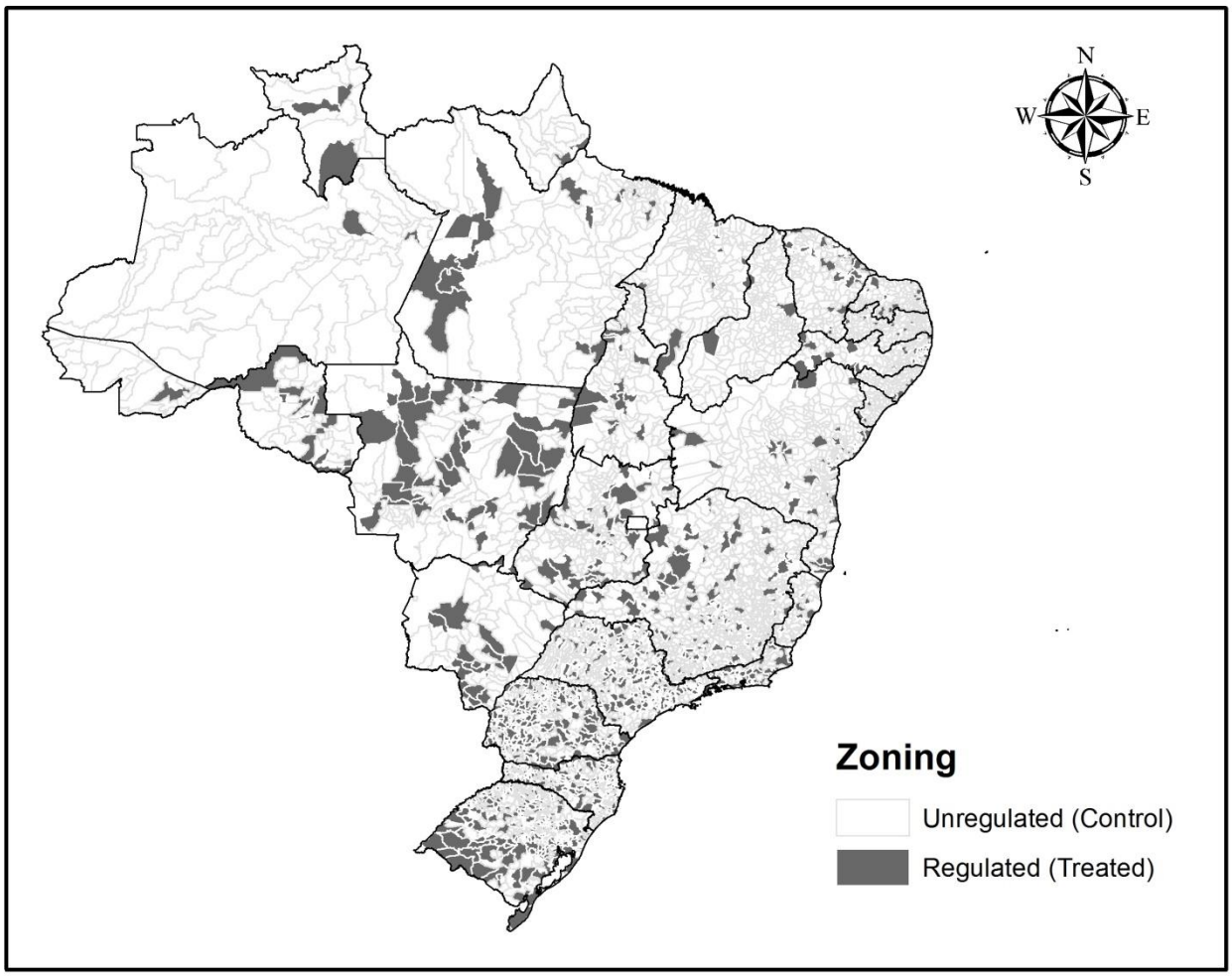
Appendix

Figure 1A – Spatial Distribution of Municipalities by Zoning Adoption



Source: Survey of basic municipal information (MUNIC), 2004.

Table 1A – Average Regression Coefficients of the Hedonic Models.

Variable	Average Coefficient
Brick Dummy (1/0)	74.4631
Number of Rooms	30.9680
Number of Bathrooms	218.7929
Number of Other Rooms	30.0606
Constant	-128.0507

Note: The figures reported in the table display the average coefficient for each variable. 5507 municipality-regressions were estimated, where the observation unit is the dwelling. The number of observations varies for each municipality.

Table 2A – The impact of Zoning: ATT using different MUNIC surveys to establish the treatment assignment.

A. Zoning MUNIC 1999	(1)	(2)	(3)	(4)
	Nearest Neighbor	10 Nearest Neighbor	Radius	Kernel
ATT	0.02053	0.03610***	0.03461***	0.05200***
	(0.0236)	(0.0203)	(0.0215)	(0.0222)
	[0.0175]	[0.0133]	[0.0105]	[0.0112]
N Treated	1186	1186	1186	1186
Off Support	34	34	72	34
Bias After Matching	3.6	2.7	2.4	2.8
Pseudo R^2	0.017	0.008	0.007	0.007
B. Zoning MUNIC 2005	(1)	(2)	(3)	(4)
	Nearest Neighbor	10 Nearest Neighbor	Radius	Kernel
ATT	0.0481**	0.0342***	0.0399***	0.0462***
	(0.0214)	(0.0164)	(0.0166)	(0.0169)
	[0.0191]	[0.0106]	[0.0096]	[0.0097]
N Treated	1131	1131	1131	1131
Off Support	5	5	26	5
Bias After Matching	2.5	1.9	1.3	1.4
Pseudo R^2	0.010	0.004	0.002	0.003
C. Zoning MUNIC 2009	(1)	(2)	(3)	(4)
	Nearest Neighbor	10 Nearest Neighbor	Radius	Kernel
ATT	0.0344***	0.0395***	0.0382***	0.0428***
	(0.0201)	(0.0161)	(0.0158)	(0.0157)
	[0.0130]	[0.0094]	(0.0084)	[0.0080]
N Treated	2111	2111	2111	2111
Off Support	3	3	30	3
Bias After Matching	3.2	1.9	1.7	2
Pseudo R^2	0.012	0.004	0.004	0.005
D. Zoning Sum	(1)	(2)	(3)	(4)
	Nearest Neighbor	10 Nearest Neighbor	Radius	Kernel
ATT	0.0421**	0.0637***	0.0488***	0.0706***
	(0.0225)	(0.0195)	(0.0218)	(0.0183)
	[0.0161]	[0.0112]	[0.0116]	[0.0094]
N Treated	2611	2611	2611	2611
Off Support	132	132	132	132
Bias After Matching	4.90	3.1	4.3	3
Pseudo R^2	0.02	0.012	0.017	0.01

Note: Analytical and bootstrap standard errors (200 interactions) are reported in round and square brackets, respectively. The Radius matching uses a 0.01 caliper and the Kernel matching is constructed using an Epanechnikov function. *** p < 0.01, ** p < 0.05, *** p < 0.1. Average rent prices were corrected for their hedonic attributes (subsection 5.2).