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DISCUSSION PAPER

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ABSTRACT

São Paulo's metropolitan area is one of the largest urban spaces in the world. As it happens with any other large metropolitan area, understanding its structure, problems and dynamics is not a simple task. The structure of cities has been studied by urban economics ever since von Thünen's land use theory was adapted to urban contexts. Research on property and housing markets have followed a related but different approach. On the one hand, housing markets have been modeled with emphasis on the specific features of properties such as durability, heterogeneity, and construction costs. On the other hand, research on real estate finance has been developing and applying a variety of valuation methods, focusing on the supply and demand adjusting mechanisms and considering properties as assets. These three areas of investigation have not always been connected in a systematic manner. Yet, we argue that there is a case for integrating them due to their intrinsic spatial dimension.

In the past decades, when the São Paulo became the national manufacturing centre, it has experienced great population growth. Many problems have emerged, especially those connected with housing such as illegal slums, flophouses, informal settlements, squatting and homelessness. This significant housing deficit indicates the need to search for alternatives in the provision of good quality housing. At the same time, there is a general spatial pattern of residential vacancy: high vacancies in central areas and low vacancies in suburbs. The city centre location advantages and urban amenities are a misuse of scarce resources. This paper attempts to contribute to this debate through an empirical analysis of the determinants of residential vacancy rates in São Paulo's metropolitan area. We use a panel of census tract level data for the years 2000 and 2010 combining standard spatial econometric methods with hedonic modelling. Our results suggest that there are two main groups of determinants: one related to local characteristics of housing markets and another constituted by individual building features. We also estimate the city historical centre determinants separately from those of the suburbs, finding consistent differences.

Keywords: vacancy rates, housing, city center, hedonic modeling

1 INTRODUCTION

São Paulo's metropolitan area is one of the largest urban spaces in the world. As it happens with any other large metropolitan area, understanding its structure, problems and dynamics is not a simple task. The structure of cities has been studied by urban economics ever since von Thünen's land use theory was adapted to urban contexts. The von Thünen model was originally developed to address spatial allocation of agricultural activities. However, the theory has been adapted to urban areas by Alonso (1964) and then by Muth (1969) and Mills (1972), arriving to the so-called Alonso-Muth-Mills model. Research on property and housing markets have followed a related but different approach. On the one hand, housing markets have been modelled with emphasis on the specific features of properties such as durability, heterogeneity, and construction costs. On the other hand, research on real estate finance has been developing and applying a variety of valuation methods, focusing on the supply and demand adjusting mechanisms and considering properties as assets. These three areas of investigation have not always been connected in a systematic manner. Yet, we argue that there is a case for integrating them, since they analyse issues embedded in urban areas, where the spatial features of markets represent a unifying theme.

The vacancy rate is the amount of vacant properties with res8pect to the total inventory. Market frictions such as searching and transaction costs, matching and price adjustment process make prices incapable of clearing the market. The first studies that incorporate vacancy on housing markets models propose the existence of a causal relationship between deviation of vacancies from a natural level and price movements.[1] The natural vacancy rate is the one at which prices tend not to change. Furthering the parallel with the labour market, Gabriel and Nothaft (2001), divide vacancy into two components: duration and incidence. A more heterogeneous stock leads to units vacant for more time, and demographic features explain a higher incidence for a specific market. Recently, for the rental market, Miceli and Sirmans (2013) proposed a "efficiency-rent" theory,[2] in which positive natural vacancy rates stimulate landlords to spend money in maintenance.

1. See Blank and Winnick (1953) and Rosen and Smith (1983).
2. Inspired by "efficiency-wage" models of the labor market.

The validity of this price adjustment mechanism is questioned by Wheaton and Torto (1994). According to them, there should be a contemporary relationship between vacancy and rents. In their model price movements depend on an equilibrium rent, which in turn depends on the net flow of consumers and past vacancy rate. Englund et al. (2008) building on the models on Hendershott, Lizieri and Matysiak (1999) and Hendershott, Macgregor and Tse (2002), propose a properties model incorporating drivers for the demand of space, apart from considering simultaneously deviations from natural vacancy rate and from equilibrium rent. These are justified by moving costs and long length of contracts.

This work adds to that discussion the focus on differences in segmented markets inside a city, specifically the historical city center.[3] If a metropolitan area is not considered one whole market, each segmented market has its correspondent natural vacancy rate and we usually see different natural vacancy rates across a city. Furthermore, urban development in rings corroborates the concentration of old buildings in the city center. This opens two possibilities: filtering down and changing neighbourhood status to lower incomes, or renewal and gentrification (Rosenthal, 2008). Anyways, if vacancies are above the natural level scarce location amenities specific of the central cities are being wasted.

São Paulo has a general spatial pattern of residential vacancy: high vacancies in central areas and low vacancies in suburbs. The city centre location advantages and urban amenities are a misuse of scarce resources. In the past decades, when the city became the national manufacturing centre, it has experienced huge population growth. Many problems have flourished, especially those connected with housing such as illegal slums, flophouses, informal settlements, squatting and homelessness. A measure of these housing problems is given by the 'housing deficit', which in 2010 amounted to 694,042 units,[4] whereas total vacant residential units are 476,112.[5] This significant housing deficit indicates the need to search for alternatives in the provision of good quality housing.

3. See Goodman and Thibodeau (1998).

4. This measure computes the number of units necessary to replace the current stock (due to poor maintenance or old age) and the number of units that have to be built to accommodate the population living in precarious conditions (Ipea, 2013).

5. In 2000 total vacant residences were 674,842 units.

This paper pretends to contribute to the empirical analysis of the determinants of vacancy rates, and its differences in historical city centers. We use a São Paulo Metropolitan Area (SPMA) panel of census tract level data for the years 2000 and 2010, combining standard spatial econometric methods with hedonic modeling. Apart from this introduction this paper has five sections. The next section presents housing studies with specific features of city centre. Then we present the São Paulo Metropolitan Area, some of its urban history and housing troubles. Section 4 presents data, facts and spatial dependence for the city center and the rest of the region. In section 5 we present the empirical modelling options and in section 6 the results. Section 7 concludes.

2 HOUSING IN CENTRAL CITIES

Alonso (1964) and then Muth (1969) and Mills (1972) expanded Von Thunen's model of concentric rings of agricultural activities to urban areas, arriving to the so-called Alonso-Muth-Mills (AMM) model. Alonso used the concept of bid-rent curves to show how land prices vary at different distances from the city centre. The bid-rent curves decrease with distance from the centre if it is assumed that residents prefer better accessibility. The resident substitutes land and other goods for accessibility if he wants to live in a more central location.

Anas, Arnott and Small (1998) argue that AMM models usually suffer from lack of dynamics. According to the authors, these models would be more useful if included time in the explanation of the residential land price schedule. If they did so, the durability of houses and the existence of vacant houses would have had to be accounted for. Following a separate analytical framework, filtering housing market models include durability as a key feature of properties. For instance Sweeney (1974) deal with the deterioration process that modifies the house quality through time. That process can be stopped if the house is properly maintained. If it is not, it filters down through the price-quality schedule. The decision to maintain a house in its original quality depends on the comparison of the new construction costs and maintenance costs.

If the flaw of AMM models is the lack of dynamics, the flaw of filtering models is the lack of location. The new construction costs include the new price of that land, consequence of changes in location valuation. Neighbourhoods change income levels, since a property that filters down do not change its location in the city. Inside a neighbourhood housing ages and quality are similar, whereas throughout the whole city there are rings of older housing closer to the city center. Rosenthal (2008) brings evidence on that process, showing the existence of cycles of housing ages and income levels in neighbourhoods. Brueckner and Rosenthal (2009) emphasize the role of housing age in the location of different income groups. Although generally in the US the rich tend to locate in suburbs, they find evidence that keeping quality (age) constant, richer households outbid poorer in more central locations.

Historical city centers tend to present quite homogeneous and old housing. If deteriorated, or economically obsolete, this fact by itself would lead to occupation by lower income residents. In spite of that, Glaeser, Kahn and Rappaport (2008) state that this is not the whole explanation for the US. The AMM model brings two drivers of intra-urban location: housing quality (age or more space) and transportation costs. These authors provide evidence that accessibility is more important than housing quality.

Apart from considering the role of transportation, and the presence of old buildings, the renewal of historical central neighbourhoods also has great influence in the valuation of that location. Brueckner et al. (1999) question why are there so many rich historical city centers, such as the Paris one. They stress the role of amenities. The endogenous ones are brought by high income residents, but there are also exogenous amenities, explained by political will to maintain historical sites.

Hence, in historical city centers not well maintained and with poor residents, there is a rationale for owners to wait for better prices, not selling or renting. Spontaneous gentrification may happen, such as found by Brueckner and Rosenthal (2009). Otherwhise, for exogenous reasons government can decide to invest more money in the renewal of historical sites.

The theory justifies vacancy only for the sake of searching processes. Wheaton (1990) helps to understand the role of vacancy in promoting social welfare. On the one hand, zero vacancy is not the best situation, as vacancy is necessary because the searching process takes time and consumers need a range of vacant units to choose from. On the other hand, excess of supply is a waste of a scarce resource. If in central cities owners are waiting for gentrification, vacancies are above the natural level and local amenities, such as better access to public transportation (Glaeser, Kahn and Rappaport, 2008), are being wasted.

3 THE CASE OF SÃO PAULO

SPMA as most of other large metropolises[6] has the well-known problems of violence, pollution, traffic congestion among many others. In spite of those problems, SPMA is a wealthy region compared to Brazil as a whole. For example, poverty rate is lower in São Paulo (4,93%) than the national average (15,2%).[7]

São Paulo was founded as a school by jesuits priests in 1554. It became prominent with coffee plantations in the end of the 19th century and boomed during the 20th century, with Brazil´s industrialization. During this period, the city experienced great population growth, receiving immigrants from different parts of the world and from many regions in Brazil. In the 1970´s manufacturing concentration in São Paulo municipality started to reverse, with factories spreading along nearby roads. It was during this period that the region became the most populous in the country and that it attracted more people. In 1960 the population was 4.7 million while in 1970, 8.1 million.[8]

In the last decades, São Paulo's economic role and population started to stabilize. At the same time, services and finance substituted manufacturing as the main economic activity (Diniz and Campolina, 2007). The central business district leaved the historical center in 1960 and started moving southwest until the river Pinheiros was reached and companies spread through its margin (Meyer, Grostein and Biderman, 2004).

The past great population growth generated many housing problems, such as low quality housing in illegal slums, flophouses, informal settlements, squatting and homelessness. Concerning income levels location, the better located low income residents live in slums near richer areas. Some central areas deteriorated buildings originated flophouses and abandoned ones were illegally occupied. Yet, the majority of low income families live in suburbs (Villaça, 2011).

6. In 2010 SPMA population was 19,6 million. It is the second biggest metropolitan region in Latin America, behind Mexico DF (IBGE 2010 Census, INEGI, 2011).
7. UNDP Brazil, Applied Economic Research Institute (Ipea) and João Pinheiro Foundation (MG): 2013 Atlas of Human Development in Brazil. Available at: <http://www.atlasbrasil.org.br/2013/> Accessed on: 10 Aug. 2013.
8. Ipeadata. Available at: <http://www.ipeadata.gov.br/>. Accessed on: 10 Aug. 2013.

Wealthy families lived in historic and expanded historic city center during the first half of the 20th century. Gradually, they changed location following the path of the CBD movement. The historical city center was totally left to lower income households (Villaça, 2011). In that area, there are evidences of too many closed units, along with evidences that owners are waiting for exogenous gentrification. (Bonfim, 2004).

4 DATA, FACTS AND SPATIAL DEPENDENCE

4.1 Data

We use the Brazilian Population Census[9] as our main source of information. Our unit of analysis is the census tract, and its dwellings stock. We used a census tract panel[10] of 2000 and 2010 years, with 21.594 observations. There are 32 municipalities in SPMA.

The Census counts all households and therefore produces information about vacant units. The information about which buildings are residential and which ones are occupied is then generated. The vacancy rate is the proportion between vacant dwellings and all residential units of a given stock. All the other features of the housing stock come from the occupied housing units only. There is no further information about vacant units beyond its total number. This happens because information on dwellings features come from a questionnaire which is answered by the unit's resident.

TABLE 1
SPMA descriptive statistics. Historical city center and the rest of SPMA
(2010 and growth 2000-2010)

	Historic Center			Rest of SPMA		
	Mean	Std. dev.	Growth 2000-2010 (%)	Mean	Std. dev.	Growth 2000-2010 (%)
Vacancy Rate (%)	9,8	5,8	-46,2	6,8	5,4	-37,5
Average chief of household income	3.180	2.202	-17,8	1.719	1.825	-18,9
Average number of bathrooms	1,50	0,62	-0,6	1,48	0,51	6,4
Units with more than 3 bathrooms ratio (%)	14	21	-4,0	11	15	19,4
Rented units ratio (%)	42	17	-0,7	21	11	14,2

(Continues)

9. Census is produced by Brazilian public agency IBGE. Available at: <www.ibge.gov.br>.
10. Consistent census tracts from both years were found by Mation (2013).

(Continued)

	Historic Center			Rest of SPMA		
	Mean	Std. dev.	Growth 2000-2010 (%)	Mean	Std. dev.	Growth 2000-2010 (%)
Chief of households more than 50 years old ratio (%)	22	8	-15,3	17	8	1,6
Apartments ratio (%)	81	27	-2,0	17	31	-5,4
Units with 1 resident ratio (%)	27	12	-10,6	9	6	-25,1
Density (km2)	60.649	119.590	12,5	23.004	52.346	1,4
Inequality of chief of household income	0,66	0,29	62,0	0,50	0,29	24,4
Inequality of the number of bathrooms	0,16	0,09	7,1	0,19	0,09	13,2
Distance to the city center (km)	2,08	0,73	-	18,07	9,35	-

Source: IBGE Census (2000; 2010).
Elaborated by the author.

Many explaining variables are also proportions: the amount of dwellings presenting a specific feature with respect to the total of dwellings in the spatial unit or the proportion of families with a certain feature with respect to the total of families. Two features are measured in terms of inequality, the chief of household income and the number of bathrooms. With them the heterogeneity of residents and the heterogeneity of housing quality are captured. Micro data were not available at the census tract level, so these indexes were calculated from grouped data for income ranges and the total of dwellings with a certain total of bathrooms.[11]

A summary of the variables for the historical city center and the rest of the SPMA is shown in table 1. The differences between center and SPMA were similar for the year 2000. Therefore, for the sake of brevity we do not show year 2000 descriptive statistics here. Yet, it is important to highlight one big change from 2000 to 2010, the total number of vacant units decreased from 674,847 in 2000 to 476,112 in 2010. This 30% fall in the total number is translated in greater negative growth in the vacancy rates. The historical city center is described as a neighbourhood with a high vacancy rate, a great proportion of apartments (81%), high density and many rented units. Income is higher than average, more people live alone and chief of households are slightly older than the rest of SPMA.

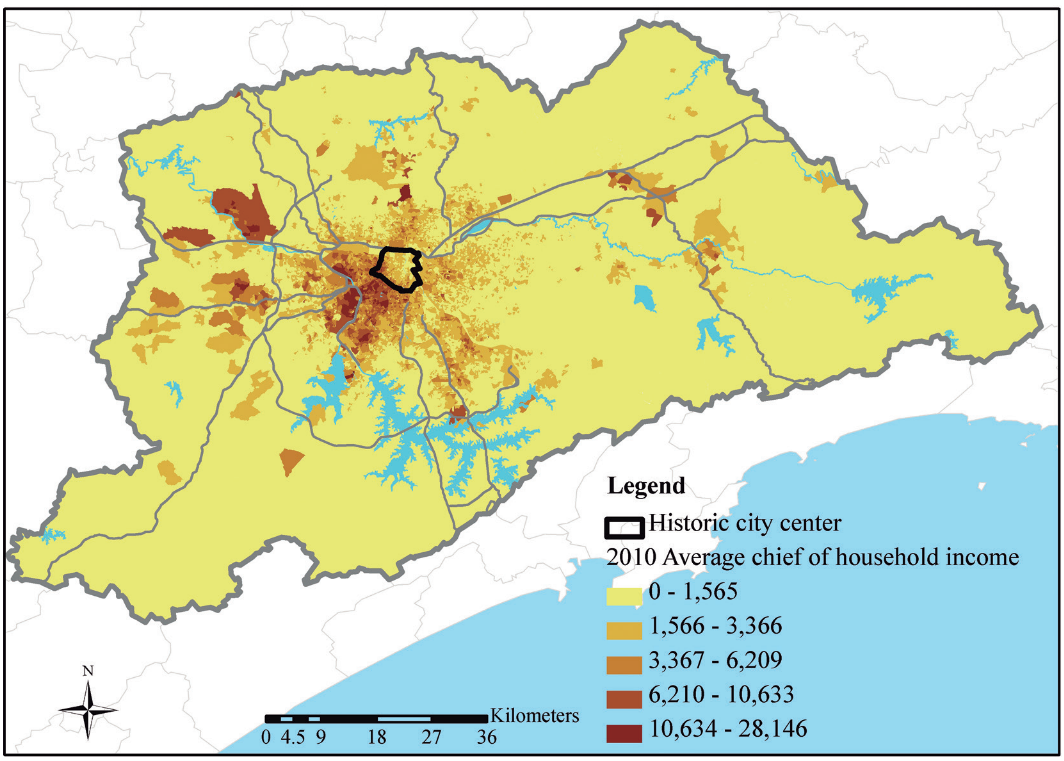
11. The index did not consider inequality inside each income/number of bathrooms range. The calculation followed chapter 6 of Kakwani (1980).

4.2 Stylized facts

In this subsection descriptive statistics are complemented by more information with the purpose of giving a more precise description of the São Paulo housing market. According to theory on housing in city center, income location, housing age and accessibility are key features.

Starting with the location of income groups, the choropleth map of 2010 average chief of the household income (figure 1) shows a quite clear concentration of high values to the southwest of the historical city center. At the same time it shows some other high levels farthest away, which correspond to clusters of gated-communities. Nevertheless, suburbs are mainly occupied by low income families.[12] The historical city center is in an intermediate situation, not being one of the most valued regions, yet with a higher than average income (table 1).

FIGURE 1
Average chief of household income choropleth map – 2010

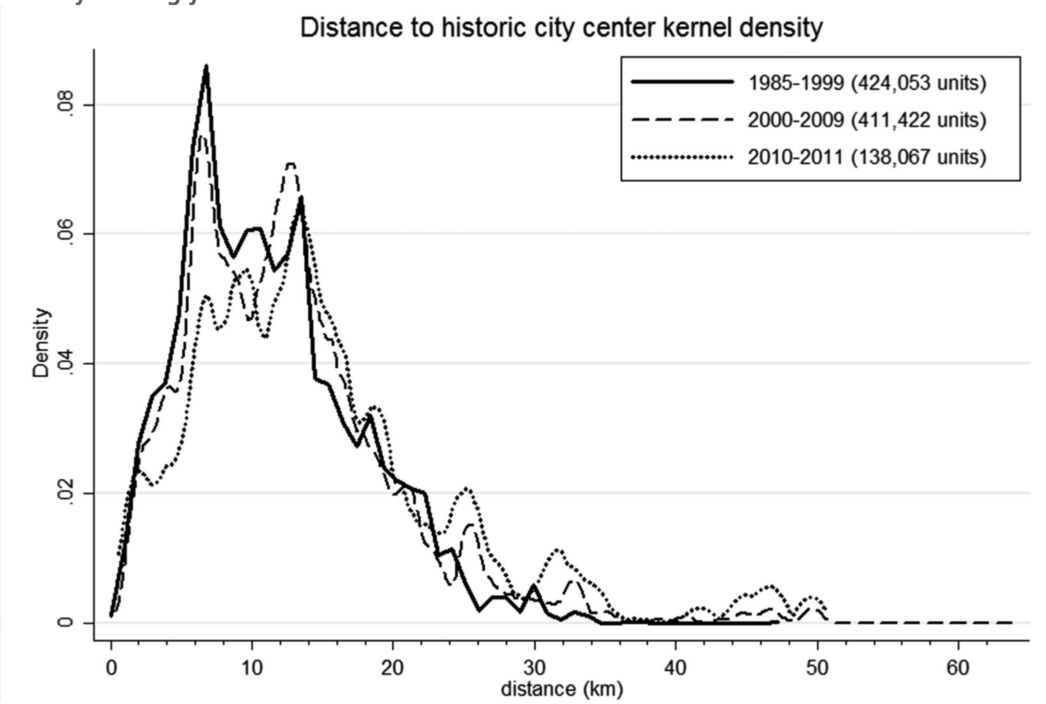


Source: IBGE Census (2010).
Elaborated by the author.

12. This 2010 spatial pattern is similar to the one in 2000.

Investigating the spatial distribution of housing age, figure 2 provides information about how far from the historic city center new housing units have started to be built. Up to a distance of 7 km frequencies grow as distance grows and older units are more frequent than newer ones. After the distance of around 13 km that situation changes to the opposite.

FIGURE 2
Kernel density estimation of new housing units distance to historic city center. Grouped by starting year



Source: University of São Paulo Center for metropolitan studies.
Obs.: 1. This data was originally produced by the real estate consulting firm "Embraesp". Available at: <http://www.fflch.usp.br/centrodametropole/upload/arquivos/2_Empreendimentos_Residenciais_85_11_RMSP_CEM.rar>. Accessed on: 08 Oct. 2013.
2. kernel = epanechnikov, badwidth = 0.4215.

These are evidences that for the years 1985 to 2011 the city has not developed compactly in concentric rings, but the new buildings are each time more distant. Since the historic center region edge is less than 7 km from the most central point, there is no substantial sign of renewal and redevelopment near the city center.

The last fact concerns the most basic intuition behind the AMM model: central locations have better accessibility. In fact, São Paulo historic center concentrates many transport infrastructures. Table 2 displays the number of residents commuting daily to work taking more than 30 and 60 minutes according to different rings of distance from the center. The historical city center concentrates the lowest ratio of residents taking more than half or one hour to go to work, an evidence of substantially good mobility amenity.

TABLE 2
Population commuting more than 30 and 60 minutes according to rings of distance from historical city center

Rings from city center	People commuting daily		People taking more than 30 minutes		People taking more than 60 minutes	
		% of total commuters		% of ring total		% of ring total
Historical city center	34.138	0,5	12.926	38	2.249	7
Between 1,5km and 3km	136.024	2	59.001	43	14.623	11
Between 3km and 9km	771.413	11	411.597	53	123.823	16
Between 9km and 15km	1.695.904	25	1.060.822	63	424.605	25
Between 15km and 21km	1.854.800	27	1.234.728	67	570.776	31
Between 21km and 33km	1.674.594	24	1.157.592	69	630.591	38
More than 33 km	711.108	10	402.846	57	197.847	28
Total	**6.877.980**	**100**	**4.339.513**	**63**	**1.964.515**	**29**

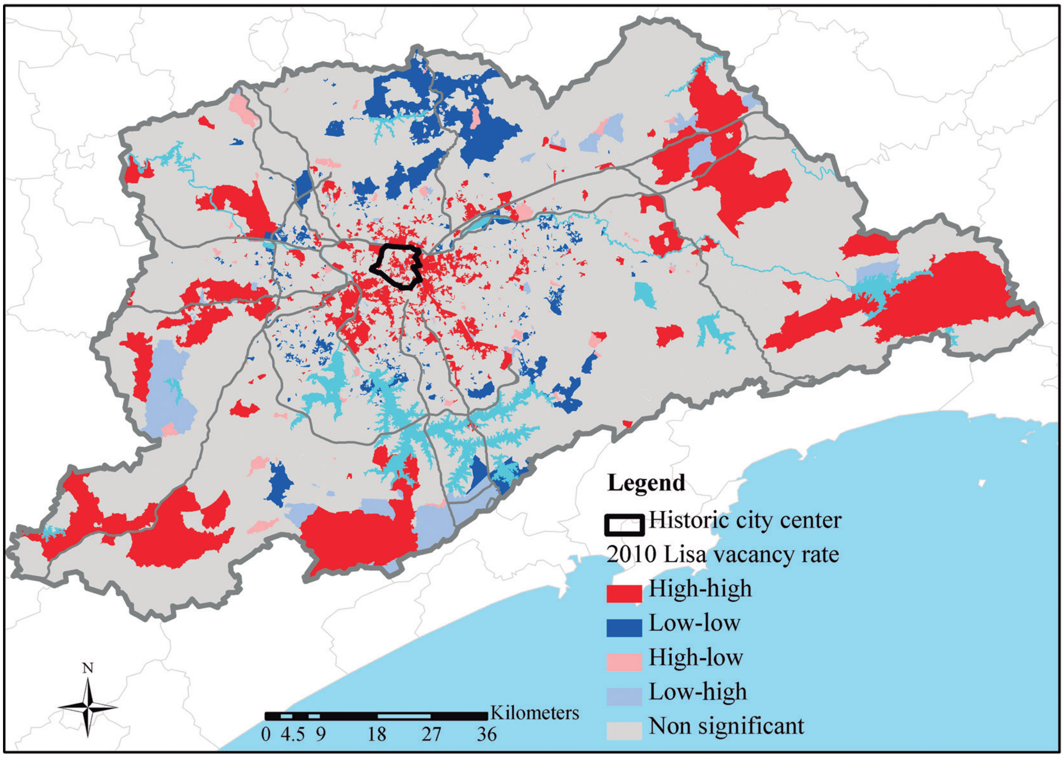
Source: 2010 IBGE Census sample.

4.3 Spatial dependence

Our data is connected to a specific spatial location within the city. Because of that, spatial dependence is expected. One of the possible causes of spatial dependence is measurement error, but census tracts are frequently so small, that we can suppose that attributes are homogeneous inside them. Another source of spatial dependence is adjacency effects. As proposed in Can (1992), these spillover effects are related to the physical quality and usage of housing units.

Starting with the feature we are investigating, spatial autocorrelation is confirmed to the vacancy rate. The global Moran's *i* test statistic is 0,3 for the year 2010 and 0,2 for the year 2000. All variables in table 1 also have significant spatial auto-correlation. The spatial pattern of vacancies with high vacancies in central locations is verified in Figure 3, a local moran´s *i* map. Vacancies are high in a central region that goes much beyond the historic city center. This concentration of high-high clusters is surrounded by low-low clusters. The high vacancies near the border of the region indicate vacancies in rural areas, outside the urbanized area. Since this is a very low density area the large red stains are not a significant proportion of the housing market.

FIGURE 3
Local moran's i map of vacancy rates clusters (2010)



Source: IBGE Census (2010).
Elaborated by the author.

5 EMPIRICAL MODEL OF VACANCY DETERMINANTS

In order to estimate the determinants of vacancy rates we follow the hedonic modelling approach. Hedonic modelling has been widely used in real estate empirical applications. In this section we briefly describe hedonic price modelling and present our application to the determinants of vacancies rates, highlighting its problems.

As properties are normally fixed in space, their physical characteristics and location attributes are inseparable. Houses and flats are heterogeneous goods, formed by a bundle of characteristics with different quality attributes. There are a large number of possible combinations of characteristics, which makes the comparison between two goods difficult. However, housing markets make consumers' preferences explicit and ranks properties through their prices. Rosen (1974) describes the housing market as a hedonic market. The hedonic regression links the property price to its attributes. The estimated attributes coefficients are their hedonic prices.

The work by Rosen and Smith (1983) and Gabriel and Nothaft (2001) use the variation across cities in vacancy rates to estimate a natural vacancy rate for each city. In this paper we adopt a different approach, explaining the vacancy distribution within the SPMA. Our methodology is similar to the hedonic modelling; trying to explain price variation using differences in houses prices within a city.

Still, we do not attempt to estimate the natural vacancy rate. Vacancy rates movements and its natural level depend upon the price adjustment mechanism. According to Wheaton and Torto (1994) the main determinants of equilibrium prices are: accessibility and the quality of the neighbourhood; the determinants of supply adjusting speed; the determinants of new residents entrance and the determinants of family mobility. If we assume that observed vacancies have a direct relationship with equilibrium prices, the determinants of the former would be also the determinants of the latter.

Hedonic modelling is valid because our regression is implicitly a hedonic prices equation. However our unit of analysis is not the house, it is the group of houses existent in a district. Hence, the estimated equation is similar to an average prices hedonic equation. We then use vacancy rates as a substitute for prices, as the dependent variable. Vacancy rates are not an element of traditional hedonic modelling perhaps because it can only be a feature of a group of properties, and never an attribute of a unit of housing.

If the assumption of the existence of segmented markets is made, there would be different price-quality schedules and hedonic prices for each segmented market. Then, in the regression, the estimated parameters should be allowed to vary throughout the segmented markets. Attributes are valued in a different way in different markets. This is going to be tested for the historical city center submarket.

Spatial econometric methods are used because spatial dependence and spatial externalities are assumed to exist. One of the big issues in housing hedonic models estimation is how to deal with the unobservable variables of location amenities. Dubin (1992) mentions the intrinsic measurement error of neighbourhood amenities and states that they should be omitted, correcting the spatial correlation with proper estimation techniques, but we chose not to do that. Instead, we assume that spatial dependence follows a spatial structure, which we do not observe yet we make assumptions about it.

Since theory supports our hypothesis of spatial externalities and adjacency effects in housing markets, assumptions about spatial structure can be viewed as less arbitrary. For cross section regressions we are going to use a spatial method of moments "general spatial two stage least squares" estimator proposed by Kelejian and Prucha (2010). It is assumed the following structure of spatial dependence in the dependent variable and the error term. The dependent variable Y is correlated to its neighbours through λ, the correlation coefficient between Y(nx1) and W(nxn).Y(nx1), and the disturbances "u" are correlated to neighbours through ρ. The neighbours matrix is queen contiguity of order one:

$$\begin{aligned} \mathrm{y} &= \lambda W\,\mathrm{y} + X\beta + \mathrm{u} \\ \mathrm{u} &= \rho W\,\mathrm{u} + \varepsilon \\ \varepsilon &\sim N(0, \sigma^2 I) \end{aligned} \tag{1}$$

For the panel estimation we use this model extended to a random effects panel, without the spatial lag of the dependent variable, following Kapoor, Kelejian and Prucha (2007). The observations for the years 2000 and 2010 are stacked and it is assumed that the disturbances "u" is the sum of a time-invariant effect and the spatial auto-correlation effect. Its variance-covariance matrix has two components, σ_v^2 for the spatial auto-correlation effect and σ_1^2 for the time-invariant effect.

6 ESTIMATION RESULTS

The cross-section regressions estimation was made in R using the "gtslshet" function in "sphet" package. For the panel regression the "spgm" function in the "splm" package was used. The following equation was estimated separately for the historic city center and the rest of SPMA in the years 2000 and 2010:

$$\text{vacancy rate}_i = \beta_0 + \beta_1{*}\text{income}_i + \beta_2{*}\text{bathrooms}_i + \beta_3{*}\text{more than three bathrooms}_i + \beta_4{*}\text{rented}_i + \beta_5{*}\text{more than 50 years old}_i + \beta_6{*}\text{apartments}_i + \beta_7{*}\text{one dweller}_i + \beta_8{*}\text{density}_i + \beta_9{*}\text{income Gini}_i + \beta_{10}{*}\text{bathrooms Gini}_i + \beta_{11}{*}\text{distance to the center}_i + \varepsilon_i \tag{2}$$

Where "i" indicates the census tract. For the panel we tested different coefficients and intercept for the center through the inclusion of interactions of these variables and the dummy variable indicating the center. The estimated equation was:

$$\text{vacancy rate}_{it} = \beta_0 + \beta_1{*}\text{income}_{it} + \beta_2{*}\text{bathrooms}_{it} + \beta_3{*}\text{more than three bathrooms}_{it} + \beta_4{*}\text{rented}_{it} + \beta_5{*}\text{more than 50 years old}_{it} + \beta_6{*}\text{apartments}_{it} + \beta_7{*}\text{one dweller}_{it} + \beta_8{*}\text{density}_{it} + \beta_9{*}\text{income Gini}_{it} + \beta_{10}{*}\text{bathrooms Gini}_{it} + \beta_{11}{*}\text{distance to the center}_{it} + \beta_{12}{*}\text{center}_{it} + \beta_{13}{*}\text{income}_{it}{*}\text{center}_{it} + \beta_{14}{*}\text{bathrooms}_{it}{*}\text{center}_{it} + \beta_{15}{*}\text{more than three bathrooms}_{it}{*}\text{center}_{it} + \beta_{15}{*}\text{rented}_{it}{*}\text{center}_{it} + \beta_{16}{*}\text{more than 50 years old}_{it}{*}\text{center}_{it} + \beta_{17}{*}\text{apartments}_{it}{*}\text{center}_{it} + \beta_{18}{*}\text{one dweller}_{it}{*}\text{center}_{it} + \beta_{19}{*}\text{density}_{it}{*}\text{center}_{it} + \beta_{20}{*}\text{income Gini}_{it}{*}\text{center}_{it} + \beta_{21}{*}\text{bathrooms Gini}_{it}{*}\text{center}_{it} + \beta_{22}{*}\text{distance to the center}_{it}{*}\text{center}_{it} + \varepsilon_{it} \quad (3)$$

Where "i" indicates the census tract and "t" the years 2000 or 2010. For instance, if coefficient β_{13} is statistically significant, the variable average income will have an impact of $\beta_{13} + \beta_1$ on the vacancy rate of the historic city center. Table 3 presents results. The 6th column presents the sum of the coefficients of variables and variables interactions with center dummy from the estimation of equation (3), with the level of significance of the interactions coefficients.

Starting with the most comprehensive regression, the panel regression results showed in the first column of table 3, it is possible to confirm many significant determinants for vacancy. The only variable not significant is the proportion of dwellings with one resident.

In spite of the general decrease in vacancy rates seen in section 4 and the decrease of the total number of vacant units, the coefficient on the dummy variable for the year 2010 in the panel regression is positive and significant. Controlling for all the other attributes, vacancy rate is around 5% greater in 2010.

TABLE 3
Residential vacancy determinants for SPMA and historic city center

	Panel 2000-2010	Rest of SPMA 2000	Rest of SPMA 2010	Historic Center 2000	Historic Center 2010	Historic center coefficients from panel[1]
Intercept	-0.0262 ***	-0.0033	-0.0287 ***	0.0359	0.0192	0.1229 ***
	(-11.7213)	(-0.3932)	(-12.1265)	(0.5034)	(0.6476)	
Income	3.15E-06 ***	4.70E-06 *	2.79E-07	-6.45E-06 .	-1.36E-06	-3.57E-06 ***
	(8.8413)	(2.0951)	(0.7326)	(-1.719)	(-1.0026)	
Bathrooms	0.0243 ***	0.0240 ***	0.0210 ***	0.0040	0.0326 **	0.0175
	(14.9054)	(4.1102)	(11.079)	(0.2038)	(3.0548)	
More than 3 bathrooms	-0.0530 ***	-0.0671 ***	-0.0441 ***	0.0452	-0.0351	-0.0237
	(-10.1632)	(-4.6541)	(-7.0434)	(0.7164)	(-1.3353)	
Rented	0.0964 ***	0.1513 ***	0.0282 ***	0.1041 **	0.0411 **	0.1170 .
	(32.7049)	(23.0178)	(8.7688)	(2.7554)	(2.716)	
More than 50 years old	0.0410 ***	-0.0626 ***	0.0530 ***	-0.0629	-0.0517	0.0399
	(8.3368)	(-4.5679)	(7.5302)	(-0.916)	(-1.3867)	
Apartments	0.0300 ***	0.0509 ***	-0.0015	0.0045	-0.0162	-0.0179 ***
	(24.7999)	(11.9509)	(-1.0696)	(0.2451)	(-1.3626)	
One dweller	-0.0018	-0.0349 *	0.0216 **	0.0237	0.0510 *	0.0131
	(-0.2998)	(-2.2559)	(3.0282)	(0.4721)	(2.0815)	
Density	-8.90E-08 ***	-1.05E-07 ***	-4.77E-08 ***	-1.32E-07 ***	-5.96E-08 ***	-1.18E-07 .
	(-16.1396)	(-4.6163)	(-3.8744)	(-4.7167)	(-3.3846)	
Income Gini	0.0135 ***	0.0211	0.0067 ***	-0.0040	0.0045	-0.0122 ***
	(9.5026)	(1.4079)	(5.1768)	(-0.0483)	(0.6169)	
Bathrooms Gini	0.0488 ***	0.0340 *	0.0040	-0.0081	0.0249	-0.0004 **
	(15.2922)	(2.1182)	(0.7959)	(-0.0907)	(0.5312)	
Distance to the center	0.0006 ***	0.0008 ***	0.0003 ***	-0.0050	-0.0119 **	-0.0258 ***
	(17.4249)	(10.6956)	(7.8351)	(-0.9663)	(-2.7353)	
lambda	0.4056	0.2732 ***	0.6539 ***	0.6906 ***	0.5321 **	
		(6.2171)	(30.7146)	(3.7038)	(3.1965)	
Rho	0.3038	-0.0223	-0.5734 ***	-0.6351 ***	-0.5498 ***	
		(-0.4179)	(-20.6752)	(-4.4021)	(-3.7745)	
Sigma^2 v	0.0032					
Sigma^2 1	0.0037					
Year 2010	0.0492 ***					
	(81.92)					
N	21,594	20,818	20,818	776	776	

Significance levels: 0% ***
0.1% **
1% *
5%

Notes: [1] These coefficients are the sum of coefficients on the first column and the coefficients of their interaction with the dummy indicator of historic center. The significance level is the one from interactions coefficients.
Obs.:the dependent variable is the census tract vacancy rate; t-values are presented in parentheses.

Some variables are linked to individual building features. The average number of bathrooms and the proportion of units with more than three bathrooms are explicitly measuring the housing structure quality. These kinds of attributes might affect vacancy through changes in consumer preferences and the correspondent need of adjustment of supply. If supply do not adapt as quick as preferences, vacancies may appear. The estimation found that a higher average of bathrooms implies higher vacancy, but the coefficient on the proportion of more than three bathrooms is negative. Given a fixed level, census tracts with higher quality units have less vacancy.

Likewise, if stock is made mainly of apartment buildings, the supply is more inelastic to changes in the demand. Apartment buildings are more difficult to rebuild than houses. They also rarely change their use. Therefore, the impact of that variable in vacancy is expected to be positive. The more inelastic the supply, the more vacant units there are. In the panel regression this positive impact is confirmed

On the other hand, other housing structure quality variables are linked to the price adjustment process speed and the mobility of residents. A rented unit will be vacant more frequently because it changes tenants more frequently than an owned one. The expected positive signal of the rented variable is confirmed. The variable measuring the proportion of older chief of households has also a positive coefficient. These families are less mobile, as a consequence of life cycles. Therefore, they should have a negative impact on vacancy, not detected in the regression. Therefore, the hypothesis about older people being less mobile might be wrong. Further analysis based on other data is needed.

Next, variables measuring census tracts markets features as a whole have also significant impacts. Average income, density and distance to the city center are neighbourhood amenities. They influence the attractiveness of neighbourhoods. Better neighbourhoods with the same price/rent level will have less vacancy. In theory, higher income is a positive amenity, distance to the center is a negative amenity, and higher density might be a negative amenity, due to congestion externalities or a positive one, due to social interaction a la Jacobs (1961). The coefficient signs do not confirm all these effects. Density seems to be a positive externality, because of the negative effect in vacancy. Distance to the center is confirmed as a negative amenity due to its positive impact. But neighbourhood average income is not decreasing vacancy level.

Still, coefficients on the inequality measures are consistent with theory. We consider the Gini coefficient on number of bathrooms a proxy for heterogeneity of stock quality and Gini of chief of household income a proxy for demand heterogeneity. The more heterogeneity, the more difficult the matching process is. More time spent in the searching process leads to higher vacancy rates. Both signals are positive.

To sum up, the effects of number of bathrooms and income neighbourhood level are quite puzzling. There is no doubt that housing quality and higher income level are valued attributes of houses and neighbourhoods. So, this is a weakness of the empirical model, because of the lack of price/rent levels and dynamics. From the theory on Englund et al. (2008), these variables might be connected not only to the valuation of space, but also to the price adjustment mechanism.

What is central to the purpose of this paper is testing if vacancy determinants are different for the historic city center. These are presented in the last column of table 3. The statistical significance of eight of them indicate that the historic city center is a separate submarket. Apart from significance, signals of significant coefficients have the oppostive signs from those for the rest of SPMA. This is evidence of a different functioning of the housing market in this submarket. Income level, density and distance to the center are positive aminities. Apartments natural increase of inelasticity of supply is compensated by another effect, probably of better valuation compared to houses, since multi-storey buildings are younger structures. Both Gini coefficients have a negative sign also indicating that heterogeneity effect on frictions are compensated by some other effect of diversity valuation.

The cross-section estimation repeats that result. In the separate regressions for the historic center less variables were significant, but significant determinants present the same sign and roughly similar coefficients from the ones from the panel estimation.

7 CONCLUDING REMARKS

In this paper we empirically investigate the determinants of vacancy rates in the SPMA. Combining hedonic modelling with spatial econometrics we find evidence of two groups of determinants. The first one relates to the dynamics of property markets and the second to property attributes. These findings are in line with the previous literature on vacancy rates and on urban economics. We also find evidence that historic central city is a submarket and its determinants work in a different way from the whole market.

The spatial pattern of residential vacancy, misusing positive amenities of the center is a motivation for the intervention in this submarket conditions. If social and housing heterogeneity leads to less vacancy, in spite of their role in frictions for the market, they can be encouraged. If apartments have less vacancy because they are newer, beyond its more inelastic supply, this is a motivation to encourage renewal programs. The connection with vacancy comes from the hypothesis that, apart from playing a role in the natural market friction, those variables explain deviations of vacancy rate above from its natural level.

Our results indicate that the methodology adopted in this paper is promising and encourages us to extend the analysis. Moreover, we acknowledge the potential limitations of the study primarily due to the lack of important controls such as housing age, price and rent levels and dynamics, and urban amenities. Including these controls are subject of further research.

In terms of the theory behind the empirical analysis there is space to build more sophisticated models pointing observable variables that capture the valuation of location, the deviation from equilibrium prices/rents and the deviation from natural vacancy rates.

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